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APPLIED MECHANICS REVIEWS

VOL. 7, NO. 11 — **MARTIN GOLAND** *Editor* — NOVEMBER 1954

OPERATIONAL MATHEMATICS

RUEL V. CHURCHILL

PROFESSOR OF MATHEMATICS, UNIVERSITY OF MICHIGAN

A LINEAR transformation of functions $F(t)$ is one that assigns to each function $F(t)$ a function $f(r)$, called the transform of $F(t)$, and has the following property. The transform of each linear combination of two functions, $C_1F_1(t) + C_2F_2(t)$, with constant coefficients, is the same linear combination of the transforms of those two functions.

According to a general theorem in the theory of functions due to F. Riesz in 1914, under natural restrictions on such transformations and under a rather broad interpretation of integrals the linear transformation can be expressed as a linear integral transformation

$$T\{F(t)\} \doteq \int_b^c K(r,t)F(t)dt = f(r)$$

The fixed limits b and c, finite and infinite, represent the ends of the interval over which the functions $F(t)$ are defined. The function $K(r,t)$ is the kernel of the transformation. For a given transformation, the same kernel is used for all functions $F(t)$.

Operational mathematics, as the term is used here, denotes the theory and application of linear integral transformations in connection with the solution of boundary-value problems in differential equations. In applications to partial differential equations, t denotes one of the independent variables of the function F, and $F'(t)$ denotes the partial derivative with respect to that variable.

LAPLACE TRANSFORMS

When the kernel $K(r,t)$ is the exponential function $\exp(-rt)$, and the limits b and c are zero and infinity, the integral transformation $\{TF\}$ is the Laplace transformation. This is the basis of the most prominent form of operational mathematics. Its applications to the solution of boundary-value problems in the partial differential equations of mechanics of the continuum, including dynamic problems in elasticity, fluid mechanics, and diffusion, have become commonplace in the past decade. Instrumentation engineering is also relying heavily upon Laplace transforms. The operational mathematics is useful in determining properties of solutions as well as in finding solutions of such problems.

It was adopted earlier, in the form of Heaviside's operational calculus, as a powerful tool for solving problems in circuits in electrical engineering. The broader study and application that followed long after its beginnings with Poisson, Laplace, and Heaviside, as well as the general recognition of the power of the Laplace transformation, date from the careful and extensive research of G. Doetsch and others, beginning some twenty years ago (1).[1]

Assuming that the function $F(t)$ has certain properties of regularity, a partial integration shows that the transform of the derivative $F'(t)$ is $rf(r) - F(0)$. This basic operational property of the Laplace transformation can be extended at once to derivatives of higher order. Thus the differential forms $F^{(n)}(t)$ are resolved into algebraic forms involving r, $f(r)$, and the initial values of $F(t)$ and its derivatives. Certain initial value problems in ordinary differential equations therefore reduce to algebraic equations in the transform of the unknown function. A large class of boundary-value problems in partial differential equations transforms into problems in ordinary differential equations.

By beginning with the above general integral transformation T for the semi-infinite interval, it can be shown that the kernel K is necessarily the exponential function $\exp(-rt)$ if T is to resolve the derivative $F'(t)$ into an expression that depends only on r, $f(r)$, and $F(0)$. Thus the Laplace transformation is characterized by its basic operational property.

In order to serve as a basis for operational mathematics, a transformation must have an inverse. The complex inversion integral furnishes the most useful formula for the inverse of the Laplace transformation. Its application often involves residue theory and contour integrals in the calculus of complex variables. But extensive tables of Laplace transforms, also of other common transforms, are now available (2). The use of tables together with properties of the transformation is often the most advantageous way of obtaining inverse transforms.

The convolution property expresses the inverse transform of the product of two transforms directly in terms of the two original functions. This property has the effect of extending tables of transforms. It gives answers to many problems in closed forms, forms that do not involve infinite series or integrals. The convolution property for Laplace transforms follows readily from the law of addition of exponents for exponential functions.

FOURIER TRANSFORMS

If the differential form $F''(t)$ is to be resolved by the transformation T in terms of the values of $F(t)$ at the ends of a finite interval, say $b = 0$ and $c = \pi$, it can be shown that $K(r,t) = \sin rt$, where $r = n$ $(n = 1, 2, \ldots)$. Then T is the

[1] Numbers in parentheses indicate References at end of paper.

finite Fourier sine transformation whose basic operational property is $T\{F''(t)\} = -n^2f(n) + nF(0) - n(-1)^nF(\pi)$. Thus a problem in differential equations that involves that derivative as the only derivative with respect to t, with a coefficient that is independent of t, and the boundary values $F(0)$ and $F(\pi)$, is adapted to this transformation rather than to the Laplace transformation with respect to t.

Similarly, if the resolution of $F''(t)$ is to be made in terms of $F'(0)$ and $F'(\pi)$, the kernel is $\cos nt$ ($n = 0, 1, 2, \ldots$), and T becomes the finite Fourier cosine transformation.

The operational mathematics of these transformations is well established. Convolution properties and other useful properties, inversion formulas, and tables exist (3).

When $b = 0$ and $c = \infty$ and both $F(t)$ and $F'(t)$ vanish at the latter limit, the resolution of $F''(t)$ in terms of $F(0)$ or $F'(0)$ leads to the infinite Fourier sine or cosine transformation, respectively, with $K = \sin rt$ or $K = \cos rt$ ($r \geqq 0$). The inverses are given by the Fourier sine or cosine integral formulas or by tables (2). When $b = -\infty$ and $c = \infty$ and both $F(t)$ and $F'(t)$ vanish at those limits, the resolution of $F''(t)$ is given by the Fourier transformation with $K = \exp(irt)$; then $T\{F''(t)\} = -r^2f(r)$.

In all these cases, the extension of the basic operational properties to higher even-ordered derivatives is obtained by an iteration. Convolution properties and other properties are known (4). The operational properties of Fourier transformations involve boundary values as distinct from the initial values involved in the Laplace transformation. Generalizations of the finite and infinite Fourier transformations, in which the boundary values of a linear combination of $F(t)$ and $F'(t)$ are introduced, are now available. They are useful, for example, when elastic edge supports are present in problems on elastic displacements.

OTHER TRANSFORMS

The differential form $F''(t) + F'(t)/t$ appears in Bessel's differential equation or in the Laplacian written in terms of cylindrical coordinates. The transformation T resolves that form, when $b = 0$, in terms of the value of a prescribed linear combination of $F(c)$ and $F'(c)$, when the kernel is $tJ_0(rt)$. Here J_0 denotes the Bessel function of index zero and r has discrete values that depend on the linear combination of $F(c)$ and $F'(c)$. The transform $f(r)$ is then a finite Hankel transform (4).

Other types of Hankel transforms arise when $c = \infty$ or when the differential form is generalized to that appearing in Bessel's equation for $J_n(t)$. Inverses are given by Fourier-Bessel series or integrals. Since the kernels are Bessel functions having no simple product or addition formulas corresponding to those of exponential functions, no convolution property has yet been found for Hankel transforms. It is expected, however, that one will soon be established for certain types, although it may be quite involved.

Similarly, the case in which $K = P_n(t)$, $b = -1$, and $c = 1$ gives the Legendre integral transformation. It resolves the form $[(1 - t^2)F'(t)]'$ that appears in Legendre's differential equation or in the Laplacian in spherical coordinates. A convolution property was established only recently. It is complicated but still useful in the operational calculus of Legendre transforms (5).

Other transformations that are serving as a basis of operational mathematics include the Mellin (2, 4) and Laguerre integral transformations. The development of the latter is still in progress and the results are not yet published.

When the differential form that is to be resolved is taken as a general one of second order with associated boundary values at the ends of the interval, the kernel becomes the characteristic functions, with a weight factor, of a corresponding Sturm-Liouville problem. The parameter r represents the characteristic numbers. The inverse comes from the Sturm-Liouville expansions. The resulting fairly general operational mathematics is not far developed. It is limited to finite intervals at present. Only a few properties of these transformations are known. The possibility of a useful convolution property seems remote.

No operational mathematics has been developed that applies directly to nonlinear problems in differential equations. But even in the case of linear problems, much remains to be done toward developing the operational mathematics based on important special cases of the Sturm-Liouville transformations.

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Letters to the Editor

3445. Concerning AMR 7, Rev. 3046 (Sept. 1954): E. J. McShane, J. L. Kelley, and F. V. Reno, Exterior ballistics.

The first sentence of the second paragraph should read: "The presentation used in the rough-and-tumble of wartime reports may be incompatible with the dignity and permanence of an academic volume."

The editors regret this error.

Theoretical and Experimental Methods

(See also Revs. 3467, 3475, 3479, 3485, 3487, 3502, 3507, 3512, 3517, 3592, 3605, 3631, 3646, 3658, 3707, 3732)

3446. Carathéodory, C., Theory of functions of a complex variable. Vol. I **(translated by Steinhardt, F.)**, New York, Chelsea Publishing Co., 1954, xiv + 301 pp.

This volume, in common with other books by the late great master of mathematical analysis, sets a new level of achievement in the literature on the theory of functions.

The book is divided into five parts. Part 1 (pp. 1–83) contains a concise treatment of complex numbers from the algebraic point of view. This is followed by the geometry of complex numbers and by the development of Euclidean, spherical, and non-Euclidean geometries. The geometry of circles and the concept of chordal distances presented in this chapter play the fundamental role in Carathéodory's unique unfolding of the theory.

Part 2 (pp. 87–114) is devoted to a brief account of some resulted from topology essential to a rigorous formulation of contour integration.

Part 3 (pp. 119–170) deals with analytic functions and includes the main results from the theory of holomorphic functions.

Part 4 (pp. 173–238) is concerned with the construction of analytic functions by the limiting processes. This part contains much that will prove novel even to an expert. The free use of P. Montel's concept of normal families and of A. Ostrowski's notion of limited oscillation enabled the author to construct proofs of great simplicity and elegance.

The final part (pp. 241–298), consisting of three chapters, deals with special functions (exponential, trigonometric, logarithmic, power, and gamma functions).

Although the volume is intended as a textbook in the complex variable theory, its main appeal will be to persons with cultivated mathematical tastes. The simplicity and elegance of the unfolding of the theory are the author's main concern, and he has produced a book of great beauty and lasting importance.

I. S. Sokolnikoff, USA

3447. Belinskiĭ, P. P., Behavior of a quasiconformal mapping at an isolated point (in Russian), *Doklady Akad. Nauk SSSR* (N.S.) **91**, 4, 709–710, Aug. 1953.

The principal theorem of the paper gives a certain generalization of the Teichmüller-Wittich theorem [*Math. Z.* **51**, 6, p. 278, 1949] and some of Šabat's results concerning differentiability of quasiconformal mapping. Proof of the Belinskiĭ theorem is based on five lemmas. Author uses notation used in other works dealing with similar problems and cited in the paper. Without use of these works, Belinskiĭ's paper cannot be understood.

K. Rektorys, Czechoslovakia

3448. Nörlund, N. E., Difference calculus [Differenzenrechnung], New York, Chelsea Publishing Co., 1954, ix + 551 pp., 54 figs.

This is a reprint of text originally published in 1924. It is a standard treatise on many aspects of difference equations. Other topics treated are Bernoulli and Euler polynomials, gamma function and related functions, summation, interpolation review, factorial series, reciprocal differences, and continued fractions. Volume is an excellent source for a basic understanding of the subject. A valuable feature is a comprehensive bibliography (pp. 464–531).

Y. Luke, USA

3449. Petrovsky, I. G. (translated by Shenitzer, A.), Lectures on partial differential equations, New York, Interscience Publishers, Inc., 1954, 260 pp., 17 illus. $5.25.

See AMR 5, Rev. 1615.

3450. Bellman, R., Stability theory of differential equations, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1953, xiii + 166 pp. $5.50.

Author attempts to consider systematically and methodically the real solutions of some real ordinary differential equations and behavior of these solutions as the independent variable increases without limit. Properties of solutions of the greatest interest are boundedness, asymptotic behavior, oscillations, and stability. Arguments used are elementary concepts of analysis. In general, the author achieves his purpose, furnishing material enabling one to enter the complicated domain of characteristic properties of differential equations without too thorough preparation on the mathematical side. The book is valuable not only to mathematicians but to theoretical and applied mechanists, aerodynamicists, and engineers as well.

Reader gets a grasp of complicated phenomena of properties of differential equations and their solutions by deducing these properties from analytic forms of equations without attempting to consider solutions themselves. Thus in an easy way, reader is acquainted with the fundamental problem in the theory of differential equations. From this standpoint, book is recommendable to thousands of applied aerodynamicists and engineers who spend an enormous amount of energy on deducing properties of solutions after obtaining these solutions. It seems that here and there the author could throw some better light upon a property in question; for example, adding some sentences on the difference between asymptotic and ordinary power series (convergent) along the lines cited in Whittaker and Watson, say, may give reader a better understanding of asymptotic series and discourage his considering convergence of asymptotic solutions, the item so common to many papers on applied mechanics. But such small items do not really diminish the value of the book.

After these general remarks, reviewer briefly outlines contents of seven chapters: 1. Brief presentation of properties of vector-matrix notation, vector-matrix equations, fundamental properties of linear systems. 2. Asymptotic behavior, stability, and boundedness of solutions of linear systems with almost-constant coefficients, asymptotic behavior, results, and series. 3. Existence and uniqueness of solutions of nonlinear systems; two methods are thoroughly discussed: successive approximations and finite

differences. 4. Stability of solutions of nonlinear differential equations with fundamental results, of Poincaré and Lyapunov and three proofs of fundamental stability theorem, conditional stability, etc.; this chapter is thoroughly elaborated. 5. Particular cases of nonlinear equations of the first order; concept of a proper solution, i.e., solution which remains finite for $t \geqq t_0$, results of Borel and Hardy referring to asymptotic behavior of real, proper, solutions. 6. Second-order linear differential equations; starting with a simple kind of such an equation, reader is introduced into more complicated forms, Liouville transformation, higher-order equations; this enables him to perform further study and to read research papers on the subject in question. 7. Emden-Fowler nonlinear second-order equation; author begins with the simplest form and gradually introduces reader into asymptotic behavior, oscillatory solutions, more complicated forms, etc. Book contains thorough list of references in each chapter and many interesting exercises. As usual, the publisher did an excellent job of printing on a good paper, with the result that the book is a valuable addition to the library of every mathematician, theoretical engineer, or applied aerodynamicist.

M. Z. Krzywoblocki, USA

3451. Hay, G. E., Vector and tensor analysis, New York, Dover Publications, Inc., 1953, 193 pp. \$1.50.

Chapter 1 defines vectors, scalar and vector products, moments of vectors with respect to points or lines, and develops multiple vector product formulas. Chap. 2 considers applications to solid and differential geometry, chap. 3, applications to mechanics of particles and systems of particles, culminating in equations of motion for rigid bodies. Chap. 4 deals with partial differential operators, usual multiple product formulas involving "del," and transformations to orthogonal curvilinear coordinates. Chap. 5 develops Green's and Stokes's theorems and introduces scalar and vector potentials. All vector chapters are treated in index notation as a preliminary to chap. 6. This defines for general coordinates in three-dimensional Euclidean space covariant, contravariant, and mixed tensors, covariant differentiation, the Riemann curvature tensor, and emphasizes invariance of form of tensor equations under coordinate transformations.

Exposition is clear and straightforward. Numerous examples are discussed in the text and there are about 200 problems, from formal exercises to questions of some geometrical or mechanical importance. A good book for American undergraduates, especially if supplemented by classroom discussions of topics not considered in the text, such as effects of singularities on the integral formulas of chap. 5. For individual study outside class it would have helped to include references to more extensive discussions of such topics, to other works on vector and tensor analysis, and to original papers involving applications to significant problems in geometry, mechanics, and other fields.

J. H. Giese, USA

3452. Zlámal, M., Asymptotic properties of solutions of linear differential equations (in German), *Math. Nachr.* **10**, 169–174, 1953.

This article is suggested by the well-known Bocher, Haupt, and Hille investigations on the asymptotic behavior of solutions of ordinary differential equations of second order. By means of successive approximations, author extends results to differential equations of any order. He deduces a very general basic theorem containing as simple special cases the preceding results by Haupt, etc. Reviewer considers the paper a valuable contribution to the theory of differential equations. The subject is also important in many technical branches (e.g., vibrations of mechanical systems), and the article can be recommended to calculating engineers and physicists.

V. Vodička, Czechoslovakia

3453. Bers, L., On mildly nonlinear partial difference equations of elliptic type, *J. Res. nat. Bur. Stands.* **51**, 5, 229–236, Nov. 1953.

A justification is given for the use of finite difference methods in solving the Dirichlet boundary-value problem for second-order quasi-linear differential equations in two independent variables under conditions for which the exact problem is known to possess a unique solution.

The corresponding difference equation is set up and shown to have a unique solution by means of a maximum modulus principle which is established first for linear difference equations. The finite difference solution is then proved to converge uniformly to that of the differential equation as the mesh size of the net of points is diminished to zero. Finally, a constructive and convergent iteration process is established for solving the finite difference problem.

A. F. Pillow, Australia

3454. Arzhanı́kh, I. S., On a certain theorem of the Hamilton-Jacobi type (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **91**, 3, 463–466, July 1953.

Let the equations of motion of a dynamical system be

$$d/dt(\partial L/\partial \dot{q}_i) - \partial L/\partial q_i = Q_i(q_1, \ldots, q_n, \dot{q}_1 \ldots, \dot{q}_n) \quad [1]$$

($i = 1,2,\ldots,n$), and assume that the Jacobian of the functions Q_i with respect to the $\dot{q}_j (j = 1,2,\ldots n)$ is different from zero. Then equations [1] may be written in the form

$$\dot{q}_i = \partial H/\partial p_i, \; \dot{p}_i = Q_i - \partial H/\partial q_i \quad [2]$$

where $H = -L + \Sigma p_i \dot{q}_i$ and $Q_i = Q_i(q_1, \ldots, q_n; \partial H/\partial p_1, \ldots, \partial H/\partial p_n)$.

Author proves a theorem which makes the integration of [2] depend on the solution of a single partial differential equation of the first order. The application of the theorem is illustrated by two examples.

E. Leimanis, Canada

3455. Horvay, G., Solution of large equation systems and eigenvalue problems by Lanczos' matrix iteration method, *KAPL Rep.* 1004, 113 pp., Oct. 1953.

Report is an excellent survey of the recent developments made mainly by Lanczos in obtaining solutions of large-scale systems of equations and new computational methods which employ minimized iteration techniques to solve eigenvalue problems. This report could easily serve as a textbook in its present form as it is very readable and displays the added feature of being self-contained. The reviewer recommends it for consideration as a textbook for advanced undergraduates or graduate students who are interested in obtaining a background in the latest computational methods.

K. M. Siegel, USA

3456. Byrd, P. F., and Friedman, M. D., Handbook of elliptic integrals for engineers and physicists, Berlin, Springer-Verlag, 1954, xiii + 355 pp. DM 36.

This is a useful volume designed to assist the applied worker in the ready evaluation of elliptic-type integrals arising in practical problems. Over 3000 integrals, formulas, and series representations are given. The notation followed is that of Legendre and Jacobi. The Weierstrass functions are briefly treated in the appendix.

Definitions and basic information concerning elliptic integrals and Jacobian elliptic functions are presented in items 100–199. In sections 200–299, elliptic integrals are expressed in terms of

integrals involving the Jacobian elliptic functions. The latter are integrated in 300 to 399. A handy feature is that each formula in 200–299 is cross-indexed to its counterpart in 300–399. The remainder of the volume is devoted to a number of miscellaneous but important topics, such as elliptic integrals of the third kind, hyperelliptic integrals, integrals and derivatives of elliptic integrals, series expansions, etc. A useful addendum is six decimal tables of the complete elliptic integrals, K, E, and the nome q with respect to the modular angle, and K, K', E, E', q, q' with respect to k^2. Also presented are values of the incomplete integrals of the first and second kind, the Jacobian zeta function multiplied by K, and Neuman's lambda function. These are sufficient for many applications, but for a complete survey of elliptic function tables and known errata the reader should consult the guide by A. Fletcher [*Mathematical Tables and Other Aids to Computation* (MTAC), **3**, no. 24, 1948] and later issues of MTAC.

In the review of "Tables of integral transforms" [AMR **7**, Rev. 2056], it was pointed out that the initial planes of Bateman could be altered since adequate tables of elementary functions, etc., were available. In preface to that work, editor remarks that material on elliptic functions is to be given by book under review and assumes that this latter volume will be used in conjunction with his tables of transforms. Scope and thoroughness of handbook are in the spirit of Bateman's original plans, and volume is a worthy addition to the mathematical workshop of the applied scientist.

Y. Luke, USA

3457. Booth, A. D., and Booth, K. H. V., Automatic digital calculators, New York, Academic Press, Inc.; London, Butterworths Scientific Publications, 1953, vii + 230 pp. $6.

This is a fine introduction to digital computers; its good balance between sections on computer components and on programming makes it generally useful. Although many of the examples apply to A.P.E.X. (the computer at Birkbeck College, London), most computer techniques which have had serious consideration are described.

First four chapters provide historical background and a general view of computing systems. Next eight chapters describe main functional units of an electronic computer, control, arithmetic unit, input-output equipment, storage devices, and elements which go to make up these units, gates, single-digit storage devices, registers, function tables, etc. Last third of the book is devoted to programming. Starting from first principles, authors lead up to discussion of flow diagrams, subroutines, optimum programming, and scaling. Presentation is largely that suggested by Goldstine and Von Neumann in a well-known series of reports, and book marks the first appearance of this material in a generally available form. Examples of detailed codes for square-rooting, division, decimal-binary conversion, and interpolation are given. Final chapter discusses application to x-ray crystal analysis, mechanical translation, games, and machine learning. There are a ten-page bibliography and name and subject indexes.

Some topics could well have been treated more fully. Parts on number representation and coded decimal systems are inadequate and reviewer does not agree that the example of finding a square root (p. 170), the first binary calculations shown in the book, will be clear to most readers. Description of program developments originating at Cambridge and Manchester is brief, although these are as important as those originating at the I.A.S., Princeton. Those features which make a machine like UNIVAC particularly useful for data processing are not well brought out. Some inaccuracies are also noted. The multiplication time of the Ferranti machine is very slightly over 2 msc, not more than 3 msc, as given on p. 18. On p. 50 it is stated that almost all machines are true binary, but this is not true for Bell machines, Harvard machines, and all commercial IBM machines—an appreciable fraction of existing computers. On p. 221 of the bibliography, "Grindley" should be "Gridley."

These criticisms notwithstanding, the book is good. Treatment is comprehensive and clear and evidently the result of years of experience and detailed knowledge of the field.

C. C. Gotlieb, Canada

3458. Blackwell, D., and Girshick, M. A., Theory of games and statistical decisions, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xii + 355 pp. $7.50.

Written by academicians for academicians, book is designed as a text for graduate students in statistics. Reviewer feels it has little value for the practicing engineer or manufacturing executive anxious to apply the game theory immediately to industrial problems.

Defining a two-person zero-sum game $G(X,Y,M)$ as a payoff function M over the product space X by Y of players' strategies, authors give examples and continue by describing pure value, mixed extension, minimax strategy, game matrixes, good strategy, convex sets and functions, along with many definitions from point-set topology. Statistical games are introduced as special cases in which the players are nature and the statistician. After defining sample spaces, random variables, probability distributions, expected values, decision functions, and risk functions, theorems concerning their use are developed. Further topics include utility, principles of choice, optimal strategies, Bayes solutions, sequential games, and comparison of experiments.

E. C. Varnum, USA

3459. Draper, C. S., McKay, W., and Lees, S., Instrument engineering. Vol. I. Methods for describing the situations of instrument engineering. Vol. II. Methods for associating mathematical solutions with common forms, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1952, 1953, xvi + 269 pp.; xxviii + 827 pp. $7; $15.

These two volumes on instrument engineering are part of a trilogy on the subject. Volume I is concerned with the expression of instrument problems in the form of mathematical equivalents and the discussion of related mathematical topics.

The second volume is devoted to the solution of the mathematical problems encountered. The authors intend that the third volume, not yet published, will be devoted to examples in which are applied the theory, methods, and techniques of the other volumes.

Dimensional analysis, performance operators, statistical methods, series representations of functions, and the frequency-response approach are topics treated in the first volume. The second opens with a discussion of the differential equations that normally arise in the analysis of instruments and the systems on which the measurements are made. Laplace transforms, weighting and transfer functions, pulse, step, and impulse disturbances, Nyquist's stability criterion, the root-locus method, and "numerical analysis" are treated in detail. The latter is concerned with the approximation to a function by triangular, rectangular, step, and ramp series. For the treatment of impulses, authors employ the function of P. A. M. Dirac rather than the treatment of Laurent Schwartz.

The authors recommend a definite procedure for handling the mathematics of instrument problems. One step is the reduction of equations to nondimensional form.

Printed by the offset process, the books are written essentially in outline form. Running summaries are carried continuously throughout these volumes, blocked out from the rest of the text. In an effort to make the information contained in equations as

self-contained as possible, authors use a very complicated symbolism.

The contents of volumes 1 and 2 apply to servomechanisms, regulators, and communication as well as to instruments. In the opinion of the reviewer, these volumes are well suited as texts and reference works to the needs of both the student and expert in the field of cybernetics.

R. Oldenburger, USA

3460. Krames, J. L., Descriptive and kinematic geometry for design engineers [Darstellende und kinematische Geometrie für Maschinenbauer], Wien, Franz Deuticke, 1952, vi + 267 pp., 306 figs., 2 tables. $2.90.

The introductory chapter defines the concept of descriptive geometry, describes its purpose and aim, stresses the fundamental importance to the work of the design engineer, outlines concisely its historical development, and surveys completely the nomenclature used in the text. The main chapters have the following headings: Conjugate orthographic projections; Conical and cylindrical surfaces; Spherical surfaces and surfaces of revolution; Ruled surfaces, screw surfaces, and graphical surfaces; Axiometric projections and parallel perspective; Kinematic geometry of the plane; Kinematic geometry of the space. The concluding chapters comprise carefully selected problems, index of subjects, and index of names. Numerous footnotes give references to the related literature. In this 2nd edition there are no essential changes; only the collection of problems was added.

The style of presentation of the different subjects is very clear and maintains high pedagogical standards. Technical applications of the material dealt with are found throughout the book. One of the major objectives of the text is to provide for the engineering student a textbook to acquire an exact thinking in three dimensions. The latter is gaining more and more importance in the field of the three-dimensional kinematics. Due to newly developed methods, the application of systematically determined three-dimensional linkages and cam drives will increase.

Reviewer believes author has made a worth-while contribution by combining descriptive geometry and kinematic geometry within one book for the purpose described above. A corresponding book written in the English language is desirable.

J. Boehm, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 3454, 3491, 3508, 3776)

3461. Singer, F. L., Engineering mechanics, 2nd ed., New York, Harper & Brothers, 1954, xvi + 525 pp.

Although this second edition retains the general plan and features of the original edition, it has been completely rewritten and embodies the suggestions received from many users of the book. The fundamental aim of the book is to show how a few basic concepts—the relation between a force and its components, the principle of moments, and Newton's laws of motion—may be combined and applied to a wide variety of practical situations encountered by engineers. The book is divided into two principal divisions: statics and dynamics. The statics division is subdivided generally into the sub-branches of force systems and applications of force systems. The dynamics subdivision is divided generally into kinematics and kinetics. The two principal divisions are approximately equal in length.

Analytical methods are emphasized throughout the book, but graphical methods have not been neglected. Graphical methods appear frequently in the dynamics division; however, all graphical methods for statics have been grouped together in a unified treatment to form the concluding chapter. Thus the last chapter, with its grouping of methods, enables the student to find quickly the particular graphical method he is seeking.

The dynamics division, in addition to excellent coverage of the usual topics of translation and rotation, plane motion, work and energy, and impulse and momentum, embraces a chapter on mechanical vibrations. All of the material on simple harmonic motion including simple, compound, and torsion pendulums, and free and forced vibrations of undamped single-degree-of-freedom systems, is relegated to this chapter.

Perhaps the outstanding feature of the book is that there are 1720 excellent illustrative exercises and problems for the student. The explanations of the illustrative exercises are complete. Throughout, the equation or theory to be applied is stated at the left-hand side of the page. In the solution, numerical values are substituted in the respective order in which the symbols appear in the equation. This procedure enables the student to follow readily the various steps of the solution without continually referring to the body of the text. In addition, many supplementary explanations are given on the use of the equations. Problems for students to work on their own have been selected to give wide variety in type and scope. They have been arranged approximately in their order of difficulty, and answers to two thirds of them are given. No problem is presented that is not preceded by an adequate text presentation, and numerical values seem to be chosen which simplify the arithmetical computations.

In general, this second edition appears to be an excellent textbook for first- and second-year engineering undergraduates.

R. L. Bisplinghoff, USA

3462. Doughtie, V. L., and James, W. H., Elements of mechanism, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, viii + 494 pp. $6.

A rewriting of the last and sixth edition of the original text of the same title by various authors and co-authors, Schwamb, Merrill, James, and Doughtie. Primarily adapted for undergraduate work in kinematics of machines, the general approach to the subject is like that of previous editions with formal improvements. Within its scope it is an excellent and orderly presentation of the usual displacement velocity and acceleration analyses applied to basic linkages; cam construction after consideration of motion by direct contact; gear construction after consideration of motion by rolling contact; belts, ropes, chains; and gear trains, including the planetary type.

In connection with velocity analysis, reviewer commends inclusion of the checking polygon and, in acceleration analysis, inclusion of Coriolis' law; also presentation of the constructions for conjugate curves for motion by direct contact, and hyperboloids; also the analytical equation (besides the vector method) for planetary gear calculations; and consideration of universal joints and differential screws. On the other hand, reviewer believes that some space given to miscellaneous mechanisms might advantageously be used for additional theory.

Problems, including a set for laboratory work, are included.

L. R. Koenig, USA

3463. Hall, A. S., Jr., and Tao, D. C., Linkage design a note on one method, *Trans. ASME* **76**, 4, 633–636, May 1954.

See AMR **7**, Rev. 2074.

3464. Boucher, R. W., Rich, D. A., Crane, H. L., and Matheny, C. E., A method for measuring the product of inertia and the inclination of the principal longitudinal axis of inertia of an airplane, *NACA TN* 3084, 39 pp., Apr. 1954.

Investigations of dynamic stability and control characteristics of airplanes require that the moments of inertia and product of

inertia be known to a high degree of accuracy. Calculated values based on airplane mass distribution are usually of insufficient accuracy, and therefore direct measurement is necessary.

Test method described is based on the spring-oscillation technique for moment of inertia determination discussed in the references, and on an airplane hoisting scheme.

The method was tried on both a special test model and full-scale fighter airplane and provides a simple, quick, and accurate means of determining the product of inertia and location of principal longitudinal axis of inertia. The hoisting scheme also permits determination of the yawing moment of inertia. The pitching and rolling moments of inertia of the airplane were determined by the spring-oscillation method.

These methods are very useful and relatively simple to use in comparison to the older method of swinging the airplane as a compound pendulum.

Additional information may be found in *AF tech. Rep.* WADC TR53-207, "An investigation of the experimental determination of aircraft inertia characteristics," Oct. 1953.

W. F. Milliken, Jr., USA

3465. Lawden, D. F., Entry into circular orbits—2, *J. Brit. interplan. Soc.* **13,** 1, 27–32, Jan. 1954.

Paper deals with the problem of navigating a rocket approaching a planet from a great distance into a circular orbit about the planet with minimum fuel consumption. The solar gravitational field was ignored, by considering both rocket and planet in a state of free fall in this field. Four different ways of approaching the planet are discussed:

1. Radius of circular orbit specified: (a) Line of approach specified; (b) line of approach not specified. 2. Radius of circular orbit not specified: (a) Line of approach specified; (b) line of approach not specified.

Navigating a rocket approaching Jupiter was considered for various cases in which the radius of circular orbit was not specified.

L. W. Hu, USA

3466. Garnier, M., Remarkable points on a trajectory. IX, X (in French), *Mém. artill. fr.* **27,** 3, 515–607, 1953.

Chapters 9 and 10 finish the very extensive work of the author on the remarkable points. They hold for trajectories vertical downward and are presented in the same manner as in chaps. 7 and 8, which are valid for shots vertical upward. Now the independent variable is the time. The researches deal with two methods (method normal and method special) described by the author in earlier works [title source, 1930 and 1949]. The number of forms mentioned in the whole publication [chaps. 1–9] has increased to more than 150 (75 for curved trajectories, 25 for trajectories vertical upward, and 53 for the two methods for trajectories vertical downward).

H. Schardin, Germany

Servomechanisms, Governors, Gyroscopics

3467. Mazelsky, B., Extension of power spectral methods of generalized harmonic analysis to determine non-Gaussian probability functions of random input disturbances and output responses of linear systems, *J. aero. Sci.* **21,** 3, 145–153, Mar. 1954.

It is shown that a lightly damped dynamic system with a relatively flat input power spectrum will have an essentially Gaussian output distribution unless the input probability function is abnormally skew. A criterion for Gaussian output is obtained in terms of the relative order of second and third input moments. This condition should not be violated for turbulence problems.

Present mathematical treatment has applications to atmospheric turbulence, tail buffeting, impact due to landing and taxiing aircraft. It is an extension of earlier work by Wiener and Clementson and is a sequel to AMR **6,** Revs. 2876, 2167, and 3827, which restricted the description of the disturbing function to either its correlation coefficient or Fourier transform. Techniques for describing probability functions in terms of their moments are discussed.

S. Kirkby, England

3468. Mercer, J. F. W., A quantitative study of instrument approach, *J. roy. aero. Soc.* **58,** 518, 83–101, Feb. 1954.

This paper provides an experimental study of, first, the preferable type of control to keep a piston-engined aircraft in localizer beam; and second, efficacy of I.L.S. approach system in landing aircraft. It is concluded that, because of beam distortions and despite variable cross winds, a "rate" term derived from beam information is less effective than one obtained from gyro compass. It is further concluded that usual cross-pointer meter is not sufficient aid to pilot, but that either the right type of automatic approach system or some such presentation as the Sperry "Zero Reader" as an aid to manual approach will help considerably to insure good landing. It is acknowledged that transition between instrument and visual flight may be critical, and overall problem involves work by experts in various fields.

L. Becker, USA

3469. Schmutz, O., Coefficient criteria for the damping intensity of transient phenomena (generalized Hurwitz conditions) (in German), *Ing.-Arch.* **21,** 1, 33–41, 1953.

A servomechanism is stable if all roots of characteristic equation have negative real parts. The Hurwitz determinantal criterion applying to this case is modified to apply to a given amount of damping, using its formulation for complex coefficients and a rotation of the axis in the complex plane of the roots corresponding to the damping. Similarly, the Bilharz criterion, which involves higher-order determinants, simpler in structure, is modified. Both criteria are shown to be equivalent for a third-order aperiodic system. Finally, cases where all roots have the same magnitude and damping are considered and standard formulas for these cases are given. It is stated that criteria are too involved for practical application.

R. Timman, Holland

3470. Leonhard, A., Determination of transient response from frequency response, Frequency Response Symp., ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-14, 15 pp.

From the well-known representation of the transient (step function) response of a linear servo system as the Laplace transform of the frequency response, author presents manual computational procedures for construction and approximate integration of a sequence of frequency-response curves which approximate the transient response. Lucid exposition and good illustrative examples make what reviewer believes to be a highly usable contribution to practical servo-design technique. Discussion of errors is not as extensive as reviewer would like, although their discussion at all is sufficiently unusual to deserve mention.

L. B. Hedge, USA

3471. Oja, V., Frequency-response method applied to the study of turbine regulation in the Swedish power system, Frequency Response Symp., ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-23, 7 pp.

Most economical use of natural power resources motivates large-scale integration of power stations of different size and nature with consumption areas into jointly operated electrical networks, especially in the case of a predominance of hydro-

power, as in Sweden, which presents an interesting example of a huge, centrally controlled system of about 3500 Mw. Even rapid load variations in such a system will assume considerable numerical values, and it becomes increasingly inconvenient to balance them through a single station. A logical solution is to let most of participating stations help in variations of load only. Variations of frequency are a criterion of load demand in the power system. Accomplishing a rational solution, therefore, involves design of a governor to perform the frequency-load control at each station and calls for adequate knowledge of dynamic characteristics of the network, which, in fact, forms the last link in a closed loop. Design of actual electric-type governor was first described by Garde in 1943.

Present paper discusses the fascinating task of measuring the Nyquist frequency response (complex frequency-load ratio) of the whole Swedish network by locking turbine governors of 95% of the total power and injecting a sinusoidal load disturbance. Response of network being known, all elements of the system are defined.

Transient speed droop δ_t and time constant τ_c of stabilizing feedback, both variable characteristics of electric governor, are determined from a graphical analysis in the familiar KG-vector locus plot. Regulating effort on part of the stations and resulting attenuation of the original load disturbance through the system are defined and serve to give rational values of δ_t and τ_c for all participating frequency-load regulating stations in this undertaking, which is already well under way toward its full realization.

Reviewer considers part of paper was available earlier through previous reports of the CIGRE Meeting, Garde's article in "Automatic and manual control" [Butterworths Scientific Publ., London, 1952], and Swedish publications. Core of the paper, the analysis determining δ_t and τ_c, was not known to reviewer and undoubtedly represents an interesting contribution toward the optimum economical design of frequency-load regulating systems.

J. R. Schnittger, Sweden

3472. Blumenthal, I. S., and Beck, F. J., Transient analysis of nonlinearized single lag servomechanisms, Proc. First U. S. nat. Congr. appl. Mech., 1951; J. W. Edwards, Ann Arbor, Mich., 155–160, 1952.

Paper deals with response to step-function input of specific second-order system containing nonlinearity in the "spring constant" term such that "spring constant" changes abruptly to another value at predetermined amplitude of variable. Attempt is made in this case to systematize very well-known techniques of solving a set of ordinary linear equations with common boundary conditions by use of graphical methods and dimensionless variables. No significant general results are obtained.

L. Becker, USA

3473. Blokh, Z. Sh., Regulation of machines [Regulirovanie mashin], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 360 pp.

This is a textbook for mechanical engineers, based on a course of lectures given at the Moscow Institute of Mechanics. It presents the elementary concepts of automatic control and stability of linear systems, but does not include any of the recent Russian work on nonlinear systems.

Book begins with a detailed discussion of engine governors, illustrating various types of control (no feedback, proportional feedback, etc.) which are possible. Later chapters deal with general linear systems. Chapter headings include: schemes for regulation of machines, statics of regulators, calculation of regulators with a small degree of nonlinearity by Chebfshev's method (essentially a method of small perturbations), basic equations of dynamics of automatic control, analysis of stability of control systems, influence of parameters of regulated system on stability of control, Mikhailov's stability criteria (usual criteria based on location of roots in complex plane), determination of stability from equation of open loop (Nyquist criterion, here called "Mikhailov-Nyquist criterion"), criteria for critical damping, performance criteria for a process controller, criteria for no overshoot, determination of parameters of regulator for given objective.

This book covers much the same ground as elementary books in this field which have appeared in English and in German, although some of the tables and graphs appear to present new information. Reviewer believes its chief interest lies in extensive references, given in footnotes, to Russian papers on control of linear systems. Entire book contains only five references to papers published outside USSR.

T. P. Goodman, USA

3474. Lossievskiĭ, V. L., Fundamentals of automatic regulation of technological processes [Osnoví avtomaticheskogo regulirovaniya tekhnologicheskikh protsessov], Moscow, Gosud. Izdat. Oboron. Prom'shlen., 1949, 227 pp.

This is a brief account of automatic control, with most of the illustrations taken from process control rather than from dynamics. In the introduction, author re-establishes priority of the Russian, Polzunov, in the field of automatic regulation [see AMR 5, Rev. 1606]. The first chapter introduces gradually a number of equations, definitions, and concepts relating to process control, but most of the theoretical content of the book is in the lengthy chap. 2. In that chapter there is a long derivation and considerable discussion of the solutions of the ordinary second-order differential equation, and a shorter treatment of a third-order equation. Following this, author introduces seven detailed examples applying the theory to various process controllers, including a level controller, concentration and pressure controllers, and several temperature controllers. Then there is a discussion of single and multiple capacity processes, the equations and behavior that characterize each, and a description of some amplitude-phase relationships.

Chapter 3, titled "Automatic regulators," describes a number of devices used in automatic process control and contains familiar sketches that may well have been taken from the literature of the different American manufacturers of automatic-control equipment. In chap. 4, author returns to theory to discuss the dynamics of regulated systems. He introduces here Vischnegradsky's diagram to establish Russian priority, then follows with discussions of the Routh-Hurwitz criterion, Kupfmuller's method, and the Nyquist criterion. The book closes with a chapter on optimization of regulation.

R. E. Gaskell, USA

3475. Ringham, G. B., and Cutler, A. E., Flight simulators. *J. roy. aero. Soc.* **58**, 519, 153–170, Mar. 1954.

History and present status of flight simulators for training of aircraft crews. British techniques, especially those used on the Comet jet-transport simulators, are emphasized.

R. M. Stewart, USA

3476. Mann, J., and Clements, B. B., Gyroscopic effect of rotors on the whirling of shafts, *Engineer, Lond.* **197**, 5118, 308–311, Feb. 1954.

Under the assumption that the change of the critical whirling speed of a rotor due to gyroscopic effect is comparatively small, authors derive a simple formula showing linear dependence of this change on the equivalent moment of inertia of the rotor (i.e., the difference between the polar moment and the moment about a diameter through the center of gravity of the rotor).

Experimental measurements are in good agreement with calculated values.

In the conclusion, this formula is applied for determining the correction of the critical whirling speed of a shaft, when a transient whirl, caused by torsional vibrations of this shaft, is present. Measurements made on seven rotors of different equivalent moments of inertia show good agreement with the theory.

V. Kopřiva, Czechoslovakia

Vibrations, Balancing

(See also Rev. 3454)

3477. Morduchow, M., On application of a quasi-static variational principle to a system with damping, *J. appl. Mech.* **21,** 1, 8–10, Mar. 1954.

See AMR **7,** Rev. 2084.

3478. Gustafson, P. N., A statical analogue for natural vibrations, *Proc. Soc. exp. Stress Anal.* **11,** 1, 147–158, 1953.

Paper describes an experimental apparatus to produce a lateral deflection curve y in a beam by a load my proportional to the deflection, which is the shape of a flexural natural mode. This is done by a cylindrical roller to which is attached a cam having the shape of an involute of a circle concentric with the roller circle. Strings are slung over the roller and over the cam, and a constant weight is hung from the cam strings. Then the equilibrium pull in the roller string is proportional to the angle of roll and, hence, proportional to the rise y of the roller string. A number of such cams are put on a horizontal rail and their strings pull on the model beam. A modification to torsional vibration modes employing the same type of cam is described.

J. P. Den Hartog, USA

3479. Kharkevich, A. A., Spectra and analysis [Spektry i analiz], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1952, 192 pp.

The stormy development of acoustics, mechanics of vibrations, and radio techniques leads to an intensive study of the spectra, harmonic analysis, and related questions. Monograph under review gives an account, from theoretical and experimental standpoint, of the present state of the subject. Intended mainly for use in radio engineering, the book is of importance also in other branches of technical science (especially in the theory of vibrations).

Content is divided into two chapters and an appendix. The first main part (up to p. 81) explains theory of the spectra; the second one (up to p. 152) informs about various methods of harmonic analysis. Appendix contains some complementary notes and examples relative to previous deductions.

Book ends with an index of the Russian literature on the subject. Reviewer calls attention of interested specialists to this small, but successful, work.

V. Vodička, Czechoslovakia

3480. Caligo, D., New analytical and numerical contribution to the study of vibrating rods (in Italian), *Cons. naz. Ricer.* no. 375, 15 pp., 1953.

Author solves problem of vibrating bars with an end fixed on an elastic support. A method is given for calculating eigenvalues of this problem in the case of nonhomogeneous rods with distribution of moments of inertia and masses expressible in series of powers. First part of report concludes with graph, table, and example. In second part, calculation of eigenvalues and of required integrals is worked out in detail. Paper ends with numerical results and tables for wide range of parameters involved.

H. Fernández Long, Argentina

3481. Melyakhovetskiĭ, A. S., Oscillatory properties of vibrations of a stressed rod (in Russian), *Prikl. Mat. Mekh.* **17,** 4, 461–464, July–Aug. 1953.

With the aid of the theory of integral equations, author establishes a series of theorems relative to a freely vibrating rod. For example, the influence function for displacements of a compressed fixed-free rod is shown to be always oscillatory for all loads which are below a certain critical value. Similar proofs are worked out for other boundary conditions.

G. Herrmann, USA

3482. Budiansky, B., and Fralich, R. W., Effects of panel flexibility on natural vibration frequencies of box beams, *NACA TN* 3070, 55 pp., Mar. 1954.

A mathematical study of the effects of sheet vibrational modes and frequencies on the basic torsion-bending modes and frequencies of box-beam structures. Simple models are examined experimentally to verify theoretical developments. Results can be used to estimate coupling effects in box-beam sections when the uncoupled panel frequency is greater than the uncoupled gross structural frequency.

J. B. Duke, USA

3483. Waller, Mary D., Concerning combined and degenerate vibrations of plates, *Acustica* **3,** 6, 370–374, 1953.

Classes of symmetry are considered for the vibration nodal patterns of free plates of regular shape. Experiments indicate that patterns must be "mechanically balanced" about one or more lines of symmetry. Only patterns of same frequency and class of symmetry can combine. In reviewer's opinion, author's rule of symmetry is inapplicable to square plates since pattern classification given for these is not in agreement with earlier work, e.g., Chladni ["Die Akustik," 1802], Ritz [*Ann. Phys.* **28,** 737–786, 1909], and Waller [*Proc. phys. Soc.* **51,** 831, 1939].

R. N. Arnold, Scotland

3484. Kumai, T., Vibration of the deck panels in ship structure, *Rep. Res. Inst. appl. Mech.* **2,** 8, 231–239, Dec. 1953.

For static deflection it is sufficiently accurate to include an effective breadth of plating when calculating moment of inertia of stiffeners and girders of rectangular panel. For vibrations, however, this way of calculation gives higher frequencies than those measured. Author considers above system elastically coupled to the plate rectangles between each pair of stiffeners and girders, giving two degrees of freedom, thereby obtaining correction factor to frequency calculated without such coupling. His factor gives frequencies in reasonable accordance with those measured on small steel panel excited by magnet with oscillating current. Calculations have also been compared with vibrations measured in some deck and casing panels in two 10,000-ton cargo ships. Also these results are not too far off, considering approximations of method.

No details have been given about effective breadth of plating used in the calculations. From references and conclusions, one gets the impression that the old method of putting effective breadth proportional to plate thickness has been applied. If this is the case, it would be interesting to see the result of using the more modern method of calculating effective breadth. The number of cases studied should also be extended.

G. Vedeler, Norway

3485. West, C. T., An application of the Laplace transformation to the study of certain problems in the dynamics of thin plates, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 127–132, Apr. 1953.

By means of a Laplace transformation with respect to time,

the dynamic thin-plate equation is reduced to the static equation of a plate on an elastic foundation. Condition is discussed that application of inverse Laplace transformation on static problem is valid. Method is illustrated by problem of rectangular simply supported plate subjected to impact at the center.

W. Freiberger, Australia

3486. Sengupta, A. M., Radial and torsional vibrations of a cylindrically aeolotropic annulus, *Indian J. theor. Phys.* **1,** 3, 125–132, Dec. 1953.

Frequency equations and equations of the nodal lines are obtained for free vibrations of a nonisotropic circular annulus having small thickness. Author considers the case of radial vibrations of the type in which elastic displacements occur only in the direction of the radius of the plate and the case of torsional vibrations of the type in which elastic displacements take place only in the direction normal to the radius of the plate.

P. G. Jones, USA

3487. Fort, T., The loaded vibrating net and resulting boundary-value problems for a partial difference equation of the second order, *J. Math. Phys.* **33,** 1, 94–104, Apr. 1954.

A rectangular net, loaded only at intersection points and rigidly attached at the rectangular boundary, is studied by means of partial difference equations. Existence and properties of characteristic numbers (eigenwertes) are established. Oscillations of solutions are characterized and discussed. Similarities between the treatment given certain cases and that used in Sturm-Liouville developments for differential systems are pointed out.

W. M. Whyburn, USA

3488. Desoyer, K., and Slibar, A., Analytical determination of the coefficient of cyclic variation of piston engines (in German), *Öst. Ing.-Arch.* **7,** 2, 100–110, 1953.

The unequal distribution of the working and resistance areas over the period causes fluctuations of the rpm of a system composed of a piston engine and a driven machine. For analyzing the degree of uniformity of such sets, the methods of J. Radinger and F. Wittenbauer are used chiefly. Though certain assumptions are required when applying these methods, in many practical cases the results are sufficiently accurate, as has been pointed out by R. von Mises. Lately, however, the demands for a considerable reduction of the coefficient of cyclic variation are continually growing so that it seems desirable to develop a method for ascertaining beforehand to any degree of precision the coefficient of cyclic irregularity to be expected of the set. In this paper, dedicated to von Mises' 70th anniversary, a method of calculation is developed permitting analysis of the variations of the angular velocity of such a set in case of steady motion.

From authors' summary by H. Bilharz, Germany

3489. Gaukroger, D. R., Natural frequencies and modes of a model delta aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2762, 32 pp., June 1950, published 1953.

Method and results of resonance tests on a 5-ft root chord by 11-ft span model are presented. Three symmetric modes for each of 10 varied inertia conditions, including tip weights, are described by frequencies, nodal, and contour lines. The last "method" is discussed in a brief appendix.

Symmetric excitation was applied at fuselage (root) center line. Model construction was representative of conventional construction with bending stiffness/torsion stiffness ratio at 0.7, semispan of 2.5. General indication is that, except for tip masses, the resonance test picture is not greatly altered by inertia changes.

Projected use of results in flutter analyses and comparison of model modes with actual aircraft studies will determine usefulness of report. These are expected to be subjects of further reports.

S. I. Weiss, USA

3490. Sanders, J. C., Influence of rotor-engine torsional oscillation on control of gas-turbine engine geared to helicopter rotor, *NACA TN* 3027, 40 pp., Oct. 1953.

A simplified rotor engine system was set up. This included engine inertia, shaft flexibility, and lag hinges. The equations of motion were derived along with the discussion of magnitude of physical parameters. A direct electronic analog was set up and a number of sample step-function responses computed. The results have been compared with test data obtained elsewhere, with good correspondence. Calculations were carried out for a 32,000-lb helicopter showing engine-speed control performance resulting from step-function disturbances.

C. D. Pengelley, USA

Wave Motion, Impact

(See Revs. 3688, 3748)

Elasticity Theory

(See also Revs. 3502, 3504, 3513, 3518, 3522, 3526, 3540, 3569, 3572)

3491. Trathen, R. H., Statics and strength of materials, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, x + 506 pp.

This is a textbook for the engineering student who is reasonably familiar with mathematical methods. Statics and strength of materials have been unified to form a first course. Chapter headings are: 1. Some fundamental concepts. 2. Bars under axial loading. 3. The truss, simple connections. 4. Statically determinate beams. 5. Twisting of circular bars. 6. Stress at a point and combined stresses. 7. Strain at a point, stress-strain relations. 8. Theories of failure for members subjected to biaxial stresses. 9. Additional methods for determining beam deflections. 10. Statically indeterminate structures. 11. Beams—special problems. 12. Columns. 13. Dynamic and repeated loads. 14. Forces in space. Each subject is illustrated with numerous carefully compiled practice problems.

Of special value is the comprehensive treatment of unsymmetrical bending, the shear center and forces in space, which are of considerable interest but are often not given sufficient attention in textbooks. In the last part of the book more than 500 well-chosen problems are to be found.

In the reviewer's opinion, a more detailed description of the modes of failure for different structural elements of building materials and especially of the behavior of beams under critical load would have been of interest from an educational point of view. The same could be said about the unstable state of structure, which is only mentioned in connection with columns.

The book is written in a clear and concise manner and is to be regarded as a valuable classroom aid.

G. Kazinczy, Sweden

3492. Loveless, E., and Boswell, A. C., The problem of thermal stresses in aircraft structures, *Aircr. Engng.* **26,** 302, 122–124, Apr. 1954.

Authors discuss briefly temperature variation with velocity, long-period effects at steady temperature, short-period effects for changing temperature, change of material properties at high temperatures, and some further investigations that are required.

B. E. Gatewood, USA

3493. Hemp, W. S., Fundamental principles and methods of thermoelasticity, *Aircr. Engng.* **26,** 302, 126–127, Apr. 1954.

Author shows that the theorem of stationary potential energy can be generalized to cover the thermal stress problem by adding to the strain energy a term involving temperature, material properties, and dilation, whence the thermal stress problem can be solved by solving an ordinary stress problem for the same body but using fictitious body and surface forces involving temperature and material properties. B. E. Gatewood, USA

3494. Thompson, A. S., Thermal stress in power-producing elements, *J. aero. Sci.* **19,** 7, 476–480, July 1952.

Author solves the thermal stress equations for the long circular tube with the temperature a function of radius. This problem is a special case of problems solved by Gatewood [*Phil. Mag.* (7) 32, Oct. 1941; *Quart. appl. Math.* **6,** Apr. 1948]. Author's results check Gatewood's results for this special case. Author further considers the particular case of the temperature a step function of the radius and examines the maximum stresses in relation to the parameters in the problem.

B. E. Gatewood, USA

3495. Mossakovskiĭ, V. I., The application of the reciprocity theorem in the determination of composite forces and moments in three-dimensional contact problems (in Russian), *Prikl. Mat. Mekh.* **17,** 4, 477–482, July-Aug. 1953.

A determination is made for the compression distribution on the base of a punch, as well as the surface, after compression for two cases; i.e., the flat plane contour ($Z = \alpha + \beta x + \gamma y$), and the circular contour ($Z = fn(\rho) \cos n\varphi$). The method assumes that the boundary conditions obtained from two-dimensional elasticity theory can serve as a suitable technique for making three-dimensional approximations because the coordinates are chosen in such a way that the plane $Z = 0$ is coincident with the two-dimensional space while the Z axis is chosen so that it is directed toward this elastic two-space. Friction is neglected in all cases. N. M. Matusewicz, USA

3496. Basilewitsch, W., Torsional problem of T, ⊏, and Z girders (in German), *Acad. Serbe Sci. Publ. Inst. math.* **5,** 5–20, 1953.

Sections studied consist of two or three rectangles without fillets at re-entrant corners. Prandtl's stress function is found for each rectangle in series form. Continuity conditions along common boundaries of rectangles yield simultaneous linear equations in coefficients. One numerical example is given for each of the three shapes. Contour lines for stress function surfaces are shown.

Reviewer notes that numerical values given for torsional rigidity are appreciably smaller than readily established lower bounds (e.g., 21.74 vs. 27.8). This discrepancy is not accounted for by the obvious omission of a factor two in the expressions for the torsional rigidity. R. E. Newton, USA

Experimental Stress Analysis

(See also Rev. 3732)

3497. Senior, D. A., Recording signals from resistance strain gauges, *Engineer, Lond.* **197,** 5121, 5122, 5123; 410–413, 446–449, 482–483; Mar., Apr. 1954.

A twelve-channel direct strain recorder without any electronic amplifier has been developed and is described. Commercially available strain gages have therefore been tested and have been found to operate satisfactorily at much higher dissipations than have commonly been used in practice. The gages show no sign of mechanical breakdown at power dissipations as high as 1 W. The zero drifts are acceptable when suitably arranged compensating gages in a Wheatstone bridge are used. A special composite gage consisting of four 800 ohm gages in parallel has proved satisfactory at powers up to 4 W. Suitably designed, sensitive galvanometers, in which a small coil and mirror are suspended on conducting tapes in a magnetic field, are coupled directly across all Wheatstone bridges. A power unit supplies power at suitable voltages for twelve strain bridges and for the motor and lamp of the recorder.

In this equipment, strain equivalent to 5 tons per square inch in steel gives a deflection of 1 cm on the film, if special gages are running at 3 W. Static strains are recorded with an accuracy of ±0.1 ton per square inch, while dynamic strains at frequencies up to 55 cps are recorded with an accuracy of ±0.25 ton per square inch. K. Fink, Germany

3498. Werner, F. D., The design of diaphragms for pressure gages which use the bonded wire resistance strain gage, *Proc. Soc. exp. Stress Anal.* **11,** 1, 137–146, 1953.

Equations and design charts for steel, dural, and magnesium are presented for design of diaphragms which give best compromise among the various requirements, such as high sensitivity, high natural frequency, wide pressure range, linear response, etc. Procedure is illustrated by some examples. Comparison is made between various materials, and some suggestions for making diaphragms are included. Paper is restricted to diaphragms of uniform thickness operating within linear range and in these respects is less general than a similar paper by Boiten [Biezeno Anniv. Vol. on appl. Mech., 305–328, Stam, 1953], which also pays more attention to selection and location of strain gages.

F. J. Plantema, Holland

3499. Eggwertz, S., and Noton, B. R., Stress and deflection measurements on a multicell cantilever box beam with 30° sweep, *Flygtekn. Försöksanst. Medd. Rep.* 53, 30 pp., Feb. 1954.

Results are given for experimental determination of strains and deflections of model wing having 30° sweep. Wing is of 24S-T aluminum alloy, assembled with glued joints, has five spars, a heavy root rib in the direction of flight, and three outboard ribs normal to the spars. Loads are applied at tip on both front and tailing spar in one case and on trailing spar alone in a second case. Error in results can be judged from fact that maximum difference between the moment computed from strain readings and from applied loads was 4%. The principal stress in cover sheets was found to parallel spars except in immediate vicinity of root, where the stress tended to be normal to root. The bending and shear stresses in rear spar at root were substantially greater than for the front spar. The deflection of front spar was greater than that for rear spar when both spars were equally loaded at wing tip. With load on rear spar only, rear-spar deflection was greater than that of front spar. S. Levy, USA

3500. Gray, R. M., Initial fringes in photoelastic models and their effects, *Proc. Soc. exp. Stress Anal.* **11,** 1, 115–118, 1953.

Paper presents method for separating initial stress pattern in photoelastic model from the final pattern under applied load so that true fringe orders may be obtained. Author demonstrates that direct algebraic subtraction may lead to considerable error.

W. Shelson, USA

3501. Durelli, A. J., Lake, R. L., and Tsao, C. H., Device for applying uniform loading to boundaries of complicated shape, *Proc. Soc. exp. Stress Anal.* **11,** 1, 55–61, 1953.

Using a pressurized rubber tube in a grooved fixture, a uni-

formly distributed load is applied to a star-shaped inner boundary of a two-dimensional photoelastic model. Tube pressure and effective pressure on the model are related by an empirical formula based on tests with a special calibrating fixture. Other applications of this method are suggested. Previous techniques are reviewed. T. A. Hewson, USA

3502. Waner, N. S., and Soroka, W. W., Stress concentrations for structural angles in torsion by the conducting sheet analogy, *Proc. Soc. exp. Stress Anal.* **11,** 1, 19–26, 1953.

Paper describes a method for determining torsional stress distribution in a structural angle by means of an electrically conducting sheet analogy. Conducting sheet used was a facsimile paper known as Western Union Teledeltos. Reviewer's experience with this paper and the electrical analogy indicates that the two provide not only a convenient but an accurate method for solving problems governed by the two-dimensional Laplace or Poisson equations. E. A. Ripperger, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 3476, 3480, 3481, 3482, 3491, 3502, 3528, 3551, 3555, 3557, 3559, 3575)

3503. Samson, D. R., The analysis of shear distribution for multi-cell beams in flexure by means of successive numerical approximations, *J. roy. aero. Soc.* **58,** 518, 122–127, Feb. 1954.

Paper presents rapidly convergent iteration method for computing shear flow due to a resultant shear force acting through shear center of section. Procedure is to (1) compute statically determinate shear flow q_0 in section neglecting interior webs; (2) divide section into original separate cells, each with its share of q_0 shear flow. Add shear flows q' to each cell to give zero twist to all. Magnitude of q' for each cell is computed from $\oint q/tds = 0$. The shear flows q' cause small twists which are balanced out by adding shear flows q''. Process is continued until desired degree of accuracy is reached. Author reduces above procedure to an arithmetic routine. Several examples are worked out including the flexural shear flow in a 14-cell beam.

Author's method is more rapid and simpler than conventional method in analyzing beams with many spar webs. Total shear distribution in highly redundant multicell beams may be determined by use of author's method in conjunction with Benscoter's numerical method for finding shear flow due to a pure torsional couple.

Author's method requires that no cross-sectional distortion occur. This may not be true where ribs are widely separated or relatively weak or where cutouts or concentrated loads are present. S. Goodman, USA

3504. Wu, N.-G., and Nelson, C. W., The stresses in a flat curved bar resulting from concentrated tangential boundary loads, *J. appl. Mech.* **21,** 2, 151–159, June 1954.

Authors present Fourier integral solutions for the stresses in a curved bar loaded by tangential loads on the circular boundaries. By superposition of these solutions and those given in previous papers for radial boundary loads, the stresses for any combination of concentrated boundary loads may be obtained.

R. J. Legger, Holland

3505. Berry, W. R., An investigation of small helical torsion springs, *Instn. mech. Engrs. Proc. (A)* **167,** 4, 375–392, 1953.

Author presents results of numerous torsion tests (made with a specially designed autographic testing machine) to determine elastic limits of helical torsion springs of various indexes (ratio of coil to wire diameters) and wire sizes. Both springs cold wound from patented wire and hardened and tempered springs were investigated; the effects of various low-temperature heat treatments (bluing) were also determined. In all cases for the heat-treated springs, it was found that the elastic limit during loading occurred at a given stress at the inside of the coil, calculated using a curvature correction factor; this was also true of the patented wire springs when loaded so as to unwind the coil (maximum stress, tension). For patented wire springs loaded so as to wind up the coil (maximum stress, compression), the calculated compressive stress, including curvature correction at the elastic limit, was approximately constant for indexes up to about 8; beyond this, the calculated tensile stress at the outside of the coil was the critical one. Design charts based on the test results are also presented. Results are of interest since they indicate that, in general, for best accuracy, curvature effects should be considered in calculating elastic limits of torsion springs.

A. M. Wahl, USA

3506. Torre, P. L., Calculation of helical springs with rectangular cross sections (in Italian), *ATA* **5,** 10, 465–471, Oct. 1952.

Essence of paper is a nomogram that presents properties of springs useful for design. Nomogram is based on standard formulas as given in Wahl's book, "Mechanical springs."

G. W. Housner, USA

3507. Brock, J. E., Matrix analysis of flexible filaments, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 285–289, 1952.

By matrix algebra, an expression for the deflection of the end of an elastic filament is found for a generalized force system at that end. In order to facilitate the mathematics, the equation of the curve of the filament is defined as a position vector. Small deflection theory is used and the cross-section variation is assumed to be gentle along the length of the filament. The method is applied to a helical wire for illustration, with several types of wire section properties used, including rectangles and circles.

H. Becker, USA

3508. Trier, H., Gear tooth forms [Die Zahnformen der Zahnräder], 4th rev. ed., Berlin, Springer-Verlag, 1954, 73 pp., 100 figs. DM 3.60.

Book is a good, extremely concise, but at the same time very thorough summary of basic principles of gear-tooth profiles, gear engagement, and practical gear applications. The sections on internal gearing, on tooth modifications for avoiding involute and other interference, and on spiral bevel and worm gearing are particularly comprehensive and well presented. Numerical examples are provided and carried through in detail.

This book should serve as a very useful review for students of gear theory and practice and as a reference source for the practicing engineer. G. A. Nothmann, USA

3509. Dean, P. M., Jr., Effects of size on gear design calculations, *Prod. Engng.* **25,** 4, 129–140, Apr. 1954.

3510. Newton, J. S., Hydraulic transmissions for locomotives, ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-122, 19 pp.

3511. Wellauer, E. J., Strength-stress life of helical gear teeth, *Proc. Soc. exp. Stress Anal.* **10,** 2, 37–59, 1952.

Plates, Disks, Shells, Membranes

(See also Revs. 3483, 3485, 3529, 3530, 3538, 3540, 3560)

3512. Rothman, M., The problem of an infinite plate under an inclined loading, with tables of the integrals of $Ai(\pm x)$ and $Bi(\pm x)$, *Quart. J. Mech. appl. Math.* **7,** part 1, 1–7, Mar. 1954.

The problem of the stress distribution in plates under inclined loads becomes interesting in connection with the action of wind or rain. Author treats the calculation for the case of an infinite plate and gives tables for the required integrals of Bessel functions.

H. Neuber, Germany

3513. Nowacki, W., A contribution to the theory of orthotropic plates (in German), *Acta Techn. Hung. Budapest* **8,** 1/2, 109–128, 1954.

Author gives a brief survey of the merits of Polish scientists, particularly M. T. Huber, concerning the development of the theory of orthotropic plates. By means of Green's function he solves several problems of the plate-strip type with various mixed boundary conditions at the transversal edge. The longitudinal edges are assumed to be simply supported.

F. M. Mueller, USA

3514. Sen, B., Note on two-dimensional indentation problems of a non-isotropic semi-infinite elastic medium, *ZAMP* **5,** 1, 83–86, 1954.

Using suitable complex potential functions, author solves problem of indentation of straight boundary of semi-infinite orthotropic plate by approximately circular punch.

A. E. Green, England

3515. Leggett, D. M. A., Summary of the theoretical work done on the stability of thin plates 1939 to 1946, *Aero. Res. Counc. Lond. Rep. Mem.* 2784, 8 pp., Sept. 1950, published 1953.

3516. Johnson, J. H., Jr., and Noel, R. G., Critical bending stress for flat rectangular plates supported along all edges and elastically restrained against rotation along the unloaded compression edge, *J. aero. Sci.* **20,** 8, 535–540, Aug. 1953.

A theoretical treatment of a flat rectangular plate supported along all edges and elastically restrained against rotation along the unloaded compression edge is presented. The energy method was used for the calculation of the critical stress of an infinitely long flat plate under bending forces in the plane of the plate. Critical stress coefficients for flat plates of finite length may be obtained from this solution. Values of this stress coefficient for finite plates having all edges simply supported and for plates having a fixed unloaded compressive edge are given.

M. Alperin, USA

3517. Schultz-Grunow, F., Green's function for elastic plates (in German), *ZAMM* **33,** 7, 227–237, July 1953.

For simply connected regions of arbitrary shape and for boundary conditions that occur in the theory of elastic plates, rapidly converging series expansions of Green's functions for $\nabla^2\nabla^2 w$ (w being deflection of plate) are given. The case of a clamped square plate with a concentrated load at the center is treated in detail.

P. M. Naghdi, USA

3518. Harvey, R. B., The elastic deformations of a plate near a hole with a stiffening rim, *Proc. roy. Soc. Lond.* (A) **223,** 1154, 338–348, May 1954.

Author considers the problem of an infinite plate with a hole bounded by a curve C_1 which is stiffened by a rim of which the material as well as the thickness is different, the rim lying between the curve C_1 and the inner curve C_2.

The plate is supposed to be in a state of simple tension at infinity and the inner boundary C_2 is taken to be unstressed. Assuming the problem to be one of generalized plane stress, the complex potential method of Stevenson [title source, **184,** p. 129, 1945] is utilized in the solution. Besides conditions at infinity, boundary conditions assumed are those of continuity of stresses and displacements across C_1 and that of no stress across C_2. The conditions thus derived are more general than those considered by previous investigators [e.g., Beskin, L., *J. appl. Mech.* **11,** (A) 140, 1944; and Wells, A. A., *Quart. J. Mech. appl. Math.* **3,** p. 23, 1950].

An exact solution of the equations is found for a circular hole with a rim of uniform width and the method is applied to find a first approximation to the complex potentials when C_1 is an ellipse or a curvilinear rectangle.

S. C. Das, India

3519. Hicks, R., Reinforced annular plates: design for minimum weight under lateral loading, *Engineering* **177,** 4598, 335–336, Mar. 1954.

An analysis of a simply supported annular reinforced plate is presented for a uniform concentric lateral loading. Expressions are developed for the cross-sectional dimensions of the reinforcement which make the weight of the combination of plate and reinforcement a minimum. The minimum weight of the structure is attained when the reinforcement, which has a given bending stiffness in the plane of the plate, is subjected to a maximum stress equal to the maximum stress of the plate. Results show weight reductions amounting to 20% in some cases. Method may be extended to include plates with built-in boundaries and other types of symmetrical loading.

R. E. Heninger, USA

3520. Kerkhof, W. P., Stresses for pressure vessels and boilers up to 650°F, *Welding J.* **33,** 5, 239-s–251-s, May 1954.

From an analysis based on simplifying assumptions concerning plastic stresses, author concludes that pressure vessels of ordinary carbon steel may be designed for membrane stress of two thirds the yield point and equal superimposed bending stress. Author asserts that residual stresses induced by fabricating procedures nearly always reach the yield point, and so, without stress relieving (not considered necessary with riveted vessels), the material is inevitably stressed to the yield point regardless of the allowable membrane stress used in design. He points out that service failures are of brittle character, due to triaxial stress concentration caused by cracks, etc., and are to be prevented by correct design and fabrication.

To some designers, accustomed to a code that limits membrane stress to one quarter of the ultimate, author's recommendations will seem bold, but they are in line with present design trends and find support in the records of vessels that have given years of service in spite of discontinuity stresses shown by measurement to reach the yield point.

R. J. Roark, USA

3521. Gruber, E., Curved prismatic shells (in German), *Bautech.-Arch.* no. 7, 62–102, 1953.

Author extends theory of long straight prismatic shells to constructions curved to circle in plan as used in arenas, hangars, and bridges. Based on standard analysis, general equations are developed for bending moments, direct and shearing forces in shell, edge beams, and stiffening beams under symmetrical and antisymmetrical loading, and the deformations are briefly considered. The analysis is illustrated by an example.

Reviewer considers method applicable only to shells of small amount of longitudinal curvature because author has neglected

influence of torsion, which becomes increasingly important as radius of curvature of longitudinal axis is decreased.

G. G. Meyerhof, Canada

3522. Srinath, L. S., and Acharya, Y. V. G., Stresses in a circular ring, *Appl. sci. Res.* (*A*) 4, 3, 189–194, 1954.

The stresses in a circular ring are found by an elementary theory and compared with the values obtained for a particular one by the authors in previous experiments. There is a good agreement and it is concluded that for rings of like proportion the elementary theory can be safely used. From authors' summary

3523. Gross, N., Experiments on short-radius pipe-bends, *Instn. mech. Engrs. Proc.* (*B*) **1B**, 10, 465–479, 4 plates, 1952/1953.

This paper and a succeeding one (see following review) are supplementary to each other. Extensive discussions and a list of references that apply to both papers are given at the end of the second paper.

Full-scale pipes were studied. They consisted of short-radius bends (ratio of bend radius to pipe radius about 3) of 90° angle of turn, with straight sections welded to the ends of the bends. Measurements were made of strains on the inside and outside surfaces of the bend when suitable loads were applied to the pipe system. Measurements were also made of deflections, flexibility factors, and collapse or failure loads. Calculations were performed from which stresses and deflections were determined, and comparison of the theoretical and experimental work is given. Previous workers have ignored the "hoop" stresses in curved tubes caused by in-plane bending moments. The author shows that the addition of these stresses to the transverse stresses, caused by deformation of the cross section of a pipe by the in-plane bending moment, results in the transverse surface stress on the inside wall of the pipe bend being larger (up to about 50%) than that on the outside surface. However, if von Kármán's analysis is used, including at least three terms in the approximate series solution, and if consideration is given to the hoop stresses caused by in-plane bending, then this method will satisfactorily determine the flexibilities of, and stresses in, pipe bends of short radius.

Experiments include tests with the pipe subjected to internal pressure. For the relatively thin-walled tube, satisfactory estimates of the stresses could be obtained by assuming that the pipe bend behaves like a thin-walled torus of circular cross section. Failure, due to pressure, occurs at the inside of the bend and requires a considerable increase in pressure after initial yielding.

I. Vigness, USA

3524. Gross, N., and Ford, H., The flexibility of short-radius pipe-bends, *Instn. mech. Engrs. Proc.* (*B*) **1B**, 10, 480–491, 1952/1953.

The preceding review describes a companion paper [see also AMR **7**, Rev. 2122]. Full-scale 90° pipe bends of short radius (1.5 pipe diam) were used. Long tangents were attached to the ends of the bends through which loads were applied. Loading included internal pressures in some cases. Measurements were made of deflections and strains. Strain measurements were made on both the inside and outside surface of the pipe bend. Comparison curves showing stresses around the inside and outside surface of the pipe bend, obtained from experimental values and from calculations using von Kármán's results to a three-term series approximation, are in good agreement, particularly for peak values. The stresses caused by internal pressures superimpose on the stresses caused by the bending moments in an ordinary manner.

In order to provide information of direct use for design consideration, the various components of stress, at any given location, have been combined to provide a single equivalent stress. This was obtained by the shear-strain energy theory of von Mises. Curves are presented of the maximum equivalent stress factor for a wide range of pipe parameters. The work is limited to in-plane bending.

An extensive series of discussions follow the paper. Consideration was given as to whether it is proper to neglect the local transverse bending stresses when it is known that they are of greater magnitude than the general longitudinal stresses. The general opinion was that this is improper. (The reviewer shares this opinion where many load cycles or fatigue conditions are involved and where stress corrosion is important, but not under other conditions.) It was shown that constraints, such as flanges near the ends of a bend, reduced the stresses in, and the flexibility of, the bend.

I. Vigness, USA

Buckling Problems

(See also Revs. 3491, 3566, 3567)

3525. Brooks, W. A., Jr., and Wilder, T. W., III, The effect of dynamic loading on the strength of an inelastic column, *NACA TN* 3077, 29 pp., Mar. 1954.

The analysis carried out for idealized inelastic H-section columns indicates that, for end motion with given velocity of the column ends, the static load is a conservative approximation.

One may observe that (a) the stress-strain relation is taken to be independent of time, and (b) the form of deflection is taken to be an arc of sinusoid between the pinned ends. Both these assumptions are on the conservative side. C. Riparbelli, USA

3526. Bleich, H. H., Refinement of the theory of torsional buckling of thin-walled columns, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 191–195, Apr. 1953.

The usual method of obtaining the energy expression for torsional buckling of axially loaded columns contains an inconsistency because different states of displacement are used for the derivation of the strain energy and of the change of potential energy of the load. The inconsistency is traced to the fact that the effect of second-order torsional stresses was neglected, and the paper presents a revised method.

The usual and the refined derivations give identical results only if the load is uniformly distributed. In addition, the refined derivation indicates that there are certain unusual distributions of the load for which the column will twist prior to reaching a critical load, a fact which has not been noticed before.

From author's summary by C. B. Matthew, USA

3527. Csonka, P., Stability of beams of rectangular cross section suspended at their ends (in German), *Acta Techn. Hung. Budapest* **8**, 1/2, 79–90, 1954.

Author studies the problem of the sidewise buckling of a beam of constant rectangular cross section suspended at its ends. The beam is assumed to be uniformly loaded by its own weight or by load uniformly applied along its neutral axis. The points of suspension on the ends of the beam are distance e above the centroidal axis. It is assumed that the ends are free to twist. The two differential equations of bending and that of twisting are used to derive the second-order differential equation with variable coefficients which defines sidewise stability. This equation, subject to the appropriate boundary conditions, is solved in terms of an infinite series. The derived characteristic equation also contains an infinite number of terms and its roots give the eigenvalues or buckling loads. In case the height e is small compared with the

depth of the beam, a very simple formula is obtained for the buckling load. As expected, the solution shows that, if e is zero, the critical load also becomes zero.

The solution of this problem is a useful addition to those in the literature for sidewise buckling of beams with simply supported ends and with fixed ends. W. H. Hoppmann, II, USA

3528. Deuker, E. A., Exact solution of the eigenvalue problem related to the lateral buckling of a cantilever beam (in German), *Ing.-Arch.* **21**, 5/6, 399–408, 1953.

The lateral buckling of a cantilever beam (first treated by L. Prandtl) finds here a formal and exact mathematical treatment, accounting for the primary state of bending from which the lateral buckling starts as well as for the occurrence of secondary torsion due to the bending of eventually present flanges. The problem is represented by an integral equation (with a symmetrical and explicitly given kernel), which is obtained by the use of well-known variational considerations.

C. B. Biezeno, Holland

3529. Strasser, A., Buckling of stiffened plates (in German), *Öst. Ing.-Arch.* **7**, 3, 262–270, 1953.

Paper considers the critical buckling load of a simply supported rectangular plate reinforced by strip stiffeners parallel to the edges of the plate and loaded on two opposite sides in the middle plane. Assuming a double Fourier series solution for the deflection, the critical buckling load is obtained, from the energy of deformation, as a function of the number of stiffeners. Finding the stationary values of the energy leads to an infinite system of linear equations for the coefficients in the Fourier series. Author attempts to represent the coefficients of this system of equations, from which the buckling load is obtained, in a schematic matrix representation. Reviewer believes this representation is of little, if any, usefulness in the solution of the problem. So far as reviewer can see, author himself makes no explicit use of these schematic matrixes to solve particular examples.

Author first considers a plate stiffened by rigid stiffeners and then by elastic stiffeners. Finally, he considers an approximation to the flexural rigidity of the strip stiffeners which will produce particular types of buckling modes.

The analysis is difficult to follow and is obscured by the fact that some of the notation used is never defined. In one instance, equations are nondimensionalized with no mention made that this is being done, and, in fact, the nondimensional form is set equal to its dimensional counterpart.

Reviewer disagrees with some of the author's results, but this may be due to a misinterpretation of the undefined notation.

H. J. Weiss, USA

3530. Scheer, J., New buckling values of reinforced rectangular plates (in German), *Stahlbau* **22**, 12, 280–282, Dec. 1953.

Paper presents results of theoretical buckling-load calculations for two basic configurations. The first is a rectangular plate with two identical longitudinal stiffeners located along the half- and quarter-width lines. This plate is treated for the cases of applied shear and applied in-plane bending, and results are given in graphical form for a broad range of dimensions and stiffnesses. The second configuration is a rectangular plate with two stiffeners which bisect it lengthwise and widthwise. Applicable theory is presented for the analysis of the second configuration buckling in shear, but no numerical results are given. The Ritz method is used, employing only a few terms in the Fourier expansion, so that errors of 5% in order of magnitude may be expected.

S. B. Batdorf, USA

3531. Schmitt, A. F., The buckling effectiveness of double-reinforced sheet, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 11–13, Apr. 1953.

A theoretical analysis is presented for the buckling strength of riveted spot-welded or resin-bonded reinforced doublers on webs or flanges. The approach employed is Bijlaard's method of split rigidities [AMR **5**, Revs. 1359, 3375], which reduces the problem to the calculation of the buckling loads for the two faces acting independently, for a "reduced panel" having zero flexural stiffness in the faces and core infinitely rigid in shear, and for a reduced panel with infinite axial stiffness in the faces. These quantities calculated for a rectangular panel of arbitrary dimensions. No comparison made with experiment. S. B. Batdorf, USA

Joints and Joining Methods

3532. Munse, W. H., Wright, D. T., and Newmark, N. M., Laboratory tests of high tensile bolted structural joints, *Proc. Amer. Soc. civ. Engrs.* **80**, Separ. no. 441, 38 pp., May 1954.

Paper gives information on the beneficial behavior of high tensile bolted joints subjected to static or alternating loadings. The specimens tested in this study were of three general types: two-fastener lap joints, three-fastener lap joints, and two-fastener butt-type joints. In the static tests were determined the shear-tension ratio, the influence of bolt tension and surface preparation on the ultimate strength, and the load-slip characteristics for the different types of joints. The fatigue tests were conducted in the 50,000 and 200,000-lb fatigue-testing machine at the University of Illinois under reserved stress cycles and in some cases under zero-to-tension load cycles, to get results on the fatigue strength of the bolts and plates. In the tests on butt-type joints, four factors were studied: bolt tension (23,600–65,000 lb/bolt), bolt diameter ($^5/_8$–1 in.), length of grip ($1^3/_4$–$3^3/_4$ in.), and fastener type (rivets or bolts). It is of interest to note that, if there is no slip in the joints, a fatigue failure in the bolts can be avoided and that the fatigue strength of bolted joints is about 25% greater than that of similar riveted joints.

M. Hempel, Germany

3533. Fisher, F. F., and Brown, G. J., Tube expanding and related subjects, *Trans. ASME* **76**, 4, 663–674, May 1954.

See AMR 7, Rev. 1438.

3534. Huff, H. A., Jr., and Kugler, A. N., Welding tubes to tube sheets. Brazing process used on tubes of unfired heat-transfer equipment, *Mech. Engng., N.Y.* **76**, 5, 421–425, May 1954.

See AMR 7, Rev. 2813.

3535. Dike, K. C., Evaluation of alloys for vacuum brazing of sintered wrought molybdenum for elevated-temperature applications, *NACA TN* 3148, 13 pp., May 1954.

3536. Homes, G. A., and van Leemput, J., Application of ultrasonics for the investigation of welds (in French), *Rev. Soudre* **9**, 4, 214–225, 1953.

3537. Gillemot, L., Novel method of speeding up manual arc welding (in Russian with English, French, and German summaries), *Acta Techn. Hung. Budapest* **7**, 3–4, 277–292, 1953.

Much thought has been given to boosting the output in arc welding; especially heavy plate and sections take a long time. Although shielded arc automatic welding greatly increases performance as compared to manual arc welding, it cannot be applied at present to every job. An obvious way to boost the efficiency

of manual arc welding is to increase the diameter of the welding rod, but the result is not in proportion to the increase of the cross section of the filler rod; the boost in performance is by no means linear, and specific increase becomes less and less. Double rods in common coating, with a three-phase current supply, have given far better results (e.g., Kael's method).

An interesting and quite different way of increasing output is the Humboldt-Meller method, in which the welder leads one filler rod with his hand while the other rod is rotatably fixed to a special stand.

When the arc is struck with the rod held in the hand, the arc of the suspended electrode is also ignited, and the welder fills the melt of both rods into the joint. A disadvantage of this method is that the angle of inclination of the suspended electrode continually changes in relation to the joint, and, consequently, conditions of welding constantly vary. Another handicap of it is that best results have been obtained with specially coated welding rods.

Disadvantages of the methods reviewed above may be eliminated if the welder holds a common welding rod with the standard electrode holder, while placing the other rod horizontally into the joint.

From the electrical point of view, twin-rod welding presents three solutions: The ideal solution is a three-phase transformer. Two single-phase transformers can be used as well, but the combination transformer-dynamo is also very suitable. Test results of the suggested improved method may be summed up as follows: (1) Through the observation of the principle of double-rod welding, performance can be more than doubled in relation to the ordinary method, even at the low current intensity chosen on purpose at the test. (2) The operation of welding is very simple; chiefly because no particular care has to be taken to remove slag or to maintain the length of the arc. Even beginners can attain thereby much better results than with common arc welding. (3) Tests showed a 40–50% economy in energy consumption. (4) Contrary to the Humboldt-Meller method, no special coating is required on the welding rods.

From author's English summary

Structures

(See also Revs. 3489, 3491, 3499, 3520, 3575, 3576, 3766)

3538. Girkmann, K., Plate structures [Flächentragwerke], 3rd revised ed., Wien, Springer-Verlag, 1954, xvii + 558 pp., 308 figs. $15.80.

The third edition of this valuable book, dealing with equilibrium problems in the two-dimensional theory of elasticity as well as in the theory of plates and shells, differs little in organization from the second edition [AMR 2, Rev. 589]. The material on orthotropic plates, previously relegated to an appendix, is now incorporated in chap. 3. New special results have been included throughout and the treatment of certain topics in chaps. 2 and 3 has been simplified. A more detailed discussion of the bending of circular and rectangular plates deserves mention. An attempt has been made to bring the bibliography up to date; the extensive list of references at the end of each chapter remains one of the most useful features of the book.

The selection of new material from the rapidly growing literature on the subject matter of this treatise reflects the author's interests and was undoubtedly influenced by his desire to keep the book on a fairly elementary level. Consequently, more advanced analytical techniques (e.g., function-theoretic methods in plane elasticity theory) and various significant developments in the theory of plates and shells (e.g., E. Reissner's refined approximate theory of plates) have not found their way into the new edition.

E. Sternberg, USA

3539. Stüssi, F., Theory of structures. I [Baustatik], 2nd ed., Basel, Verlag Birkhauser, 1953, 370 pp. 40.05 SFr.

This is the second edition of the first volume of a two-volume sequence which, in the words of the author, "should encompass roughly the normal framework of common structural practice" (reviewer's translation). The second volume of the sequence deals with statically indeterminate problems and is currently in preparation, while the volume under review is concerned with the theory of statically determinate structures and related fields.

In organization and content, the book does not lend itself readily to use as a textbook in the American undergraduate sense. There are no problems at the end of chapters. Moreover, the subject matter exceeds by far the normal scope of the standard structural undergraduate curriculum, both as to breadth of coverage and depth of detail. It is these very shortcomings as a textbook, however, which make the present volume exceedingly valuable as a reference book for the practicing structural engineer. In an attempt to justify the claim laid out in the preface (quoted above), author treats the reader to a broad, yet thorough, outline of the problems of structural theory and their solution. Much that is contained in the book had been originally contributed by the author, such as certain topics from the field of lateral stability of beams. Comparatively recent developments of structural theory (e.g., Shanley's concept of inelastic column buckling) are included, as are the traditional topics, augmented by occasional reference to historical developments. The style is lucid throughout; the level of rigor corresponds to that expected in a book on advanced strength of materials.

In so far as traditional topics are concerned, it is believed that a sketchy summary of the contents may suffice. After a general introduction of the subject matter in the first chapter, the next four chapters deal with the basic laws of statics and their application to various plane and space structures, such as girders, trusses, arches, trussed domes, etc. Influence lines are introduced at an early stage and treated exhaustively. As may be expected, graphical and kinematic methods receive much greater emphasis than is customary in American texts; this is especially true of the use of kinematics in the construction of influence lines, which has received scant attention in the American literature in spite of its relative elegance.

Chap. 6 covers the stress aspects of the elementary beam-flexure theory, together with a discussion of the state of stress at a point and of the customary failure theories. The next chapter deals with the determination of the deflection of beams and trusses by both direct and energy methods. In chap. 8 additional topics are taken up, such as the bending of beams of variable cross section, torsion of rolled sections, and the like. Stability problems are discussed in the next chapter; in addition to column buckling, this covers both torsional beam instability and basic questions of plate buckling. String deformations, with due regard to the effect of elasticity, are finally taken up in the last chapter.

Printing and figures are clear and pleasant, as is the general arrangement of chapter headings, numbering of equations, etc. A sizable shortcoming is the omission of an index and the general inadequacy of the bibliography. With this exception, reviewer believes this volume to be an extremely valuable addition to the library of the practicing structural engineer.

E. F. Masur, USA

3540. Bažant, Zd., Klokner, F., and Hruban, K., Structural analysis [Statika stavebních konstrukcí], Technical handbook, 4 (Technický Průvodce 4), Praha, Státní, Nakladatelství Technické Literatury, 1953, xvi + 620 pp., 570 figs. 70 Kcs.

One of 29 volumes of the Technical Handbook, published as 7th

edition (1st ed. in 1917, 6th ed. in 1946). Due to great progress in many fields of this subject, all sections have been carefully scrutinized and rewritten, especially sec. II (Loading conditions, by Klokner), sec. III, L (Continuous and multiple-story frame structures, by Bažant), and sec. III, Z (Shell structures, by Hruban). Material has been added to many other sections of this very thorough handbook which presents not only a compact treatise of the most important part of structural engineering but also various simplified methods of analysis, demonstrated by numerical examples. Footnotes and bibliography in each section furnish valuable references.

Introductory chapter on procedures in engineering practice and standards is written by F. Klokner. J. J. Polivka, USA

3541. Sved, G., The minimum weight of certain redundant structures, *Austral. J. appl. Sci.* **5,** 1, 1–9, Mar. 1954.

Variation of weight of a plane, pin-jointed structure of n bars involving k redundancies is investigated under a fixed load system. Assuming any constant ratio between allowable tensile and compressive unit stresses, least weight will be attained when any combination of $n - k$ bars is arranged so as to form a determinate structure. From author's summary by A. H. Finlay, Canada

3542. Ashdown, A. J., Prismatic roof slabs with small angular change, *Concr. constr. Engng.* **49,** 1, 2, 3; 3–12, 73–80, 105–109, Mar. 1954.

Paper considers hipped plate construction in which the junction angles are quite small. Consequently, the elastic deformations at the junctions cannot be neglected, as in previous work by same author. Equations are obtained for determining longitudinal stresses, transverse moments, and shearing stresses. An example is worked out.

The effect of prestressing on the longitudinal stresses and on the deflections is studied by means of an example.

J. Michalos, USA

3543. Murakami, T., Studies on the slope-deflection method, *Mem. Fac. Engng., Kyushu Univ.* **14,** 1, 1–85, 13 pp. of tables and charts, 1953.

Slope-deflection method is applied to continuous frames having curved or multisegment members of uniform or varying cross section.

Two systems of equations are developed. The first kind expresses the end moments (and horizontal thrusts) in terms of end rotations and end displacements. The second kind expresses the end moments in terms of end rotations and displacements and the horizontal thrust or reaction. Either kind (or system) of equation can be used to solve complex problems, but the author states that the second kind of equation often leads to simpler coefficients and load terms.

A wide variety of conditions is treated, including members with inclined chords, members with one end hinged, temperature effects (including nonuniform temperature), parabolic members, A-form members, polygonal arches, haunched members, bents with monitors, multiple spans with gabled roofs or other difficult shapes, circular arches, and rings, even an oval ring.

Appendixes tabulate general expressions for end moments, thrusts, rotation angles, and horizontal displacement for a number of single-span frames; also expressions for load terms for a wide variety of loads on prismatic circular members as well as numerical tables of physical constants for such numbers.

This is a comprehensive treatment of slope deflection applied to very general type members and frames, the most general treatment reviewer has seen. A three-bay bent with polygonal-shaped beam in center span under unsymmetrical loading is reduced to the solution of four simultaneous equations.

Procedures occasionally bear a faint resemblance to the column-analogy process, which has elsewhere been suggested for use in connection with a moment-distribution analysis. No comparison with the moment-distribution process is made. Many of the problems handled would be difficult by moment distribution, but it would appear to reviewer that a skillful use of column analogy (to determine member stiffness, carry-over factor, etc.) and some form of moment distribution involving successive corrections would lead to as direct or more direct solutions in many or all cases. However, no such detailed treatment of the general subject or curved members by moment distribution is known to reviewer. P. M. Ferguson, USA

3544. Sályi, I., Addition to the theory of continuous girders, *Acta Techn. Hung. Budapest* **7,** 1–2, 125–146, 1953.

A current method of analysis of statically indeterminate structures is to render the structure determinate by inserting hinges and to calculate by some of the principles of work the moment of couples applied at the hinges for the compensation of the disrupted material coherence. In the application of this method to continuous girders, hinges are inserted over the supports; thus the well-known Clapeyron equations are arrived at. The article demonstrates that, if the beam is converted to a Gerber girder by arranging hinges at proper places on the several spans, the application of the principles of work leads to a system of equations each of which includes only a single unknown. The hinges of the Gerber girder coincide with the fixed points of the beam. With the aid of the presented method, moments over either support can be determined immediately. The article also presents an algorithm facilitating the computation of all moments over supports in a simple tabular way. From author's summary

3545. Yan, H.-T., Numerical solution for interconnected bridge girders, *Civ. Engng., Lond.* **49,** 572, 573, 574; 165–167, 265–267, 392–394, Feb., Mar., Apr. 1954.

3546. Brock, J. E., Flexibility of piping systems supported by equally spaced rigid hangers, *J. appl. Mech.* **21,** 1, 11–18, Mar., 1954.

See AMR 7, Rev. 1050.

3547. Williams, C. D., and Cutts, C. E., Structural design in reinforced concrete, New York, Ronald Press, 1954, 308 pp. $6.

A basic textbook on reinforced-concrete design. The design theory is developed and expanded from basic concepts of strength of materials. Problems on shear and bond design are integrated into the discussion on bending of beams and slabs. The strength of materials approach is carried into the discussion on eccentrically loaded columns and bending under other than principal axis loading. Unusually well-detailed illustrative problems are frequently presented throughout the text. Both the ACT and Joint Commission Codes are frequently referred to and their reasoning explained.

The initial two chapters contain preparatory material on design of concrete mixes and the moment-distribution method. Brief chapters are included on prestressing, ultimate design, and construction methods. A large section is devoted to design of circular tanks. No discussion is given on arch or bridge design.

I. A. Benjamin, USA

3548. Gyengö, T., Economic upper strength limits of steel and concrete in prefabricated (not prestressed) reinforced-concrete structures under bending load, *Acta Techn. Hung. Budapest* **7,** 1–2, 61–70, 1953.

The use of high-strength concrete and steel in reinforced concrete is of economic interest, but to boost the strength beyond a certain limit is useless, because their high strength cannot be

fully exploited. There is a limit to the strain to which materials may be subjected without causing changes in the structures impeding their serviceability, such as cracks in the concrete or a too great deflection of the structure. The Building Research Institute has tested these upper limits of the strength of materials.

As regards cracks in beams, those of an average width of 0.15 mm should be regarded as a limit. The upper limit of deflection of the girders varies according to their destination, but in building constructions, under a working load one 300th of the span, under the limit load one 200th of the span, should be regarded as the extreme limit. According to test results, the strength of a high-grade steel may still be fully exploited if its flow limit is 5650 kg/cm^2, i.e., in practice roughly between 5500 and 6000 kg/cm^2; on the other hand, concrete may be fully exploited only if its strength does not exceed 600 kg/cm^2. The use of higher-strength materials in nonprestressed reinforced-concrete structures is uneconomical and aimless.

From author's summary

3549. Cervi, S., Autocompression of reinforced concrete (in Italian), *G. Gen. civ.* **91,** 11–12, 716–717, Nov.-Dec. 1953.

3550. Fiesenheiser, E. I., Rapid design of continuous prestressed members, *J. Amer. Concr. Inst.* **25,** 8, 669–676, Apr. 1954.

Author uses kern-area concept to design prestressed beams. Combined thrust due to continuity, prestressing, and load must lie within kern boundary to avoid tensile longitudinal stresses. Various conditions of loading, changing eccentricity of thrust, must be considered and kern area made to fit envelope. From dimension of kern area, ratio of moment of inertia to area is found, following which area is made sufficient to carry thrust, thus solving the unknown factors. R. Quintal, Canada

3551. Mattock, A. H., Composite prestressed beams and in-situ slabs, *Concr. constr. Engng.* **49,** 4, 123–132, Apr. 1954.

Paper deals with a composite construction comprised of a prestressed precast beam on top of which is cast an in-situ slab, which may be reinforced so that when the slab has hardened the load is carried by the beam and the slab acting together.

From author's summary

3552. Shepley, E., Design and construction of a prestressed concrete framework, *Civ. Engng., Lond.* **49,** 573, 574; 259–261, 395–397, Mar., Apr. 1954.

3553. Curtis, A. R., and Cowan, H. J., Design of longitudinal cables in circumferentially wound prestressed concrete tanks, *Mag. Concr. Res.* no. 15, 123–126, Mar. 1954.

Expressions are derived for longitudinal bending stresses created by (and during) the circumferential prestress process. Paper includes expressions for minimum longitudinal prestress required to prevent cracking. M. J. Holley, Jr., USA

3554. Shepley, E., Test of a prestressed concrete building frame, *Mag. Concr. Res.* no. 15, 115–122, Mar. 1954.

The behavior of a multistoried building frame under vertical loading has been simulated in test to destruction of full-size replica of a single story. Reinforced-concrete columns and prestressed beams were married at joints by in-situ concrete and mild steel bars. Test confirmed that satisfactory design with adequate factor of safety against collapse can be made on the basis of elastic analysis.

From author's summary by A. H. Finlay, Canada

3555. Cowan, H. J., The strength of plain, reinforced and prestressed concrete under the action of combined stresses, with particular reference to the combined bending and torsion of rectangular sections, *Mag. Concr. Res.* no. 14, 75–86, Dec. 1953.

Author draws on various strength theories in an attempt to interpret concrete strength under combined stress. In the main he favors Coulomb's internal-friction theory with a cutoff represented by a maximum tension-stress theory, although in other parts of the paper this is replaced by a maximum tensile-strain theory, while for the ultimate strength of plain and reinforced concrete in pure torsion the assumption of full plasticity is said to give results consistent with experiment.

The main body of the paper presents an analysis of combined bending and torsion of plain and reinforced-concrete beams based on a combination of Coulomb's and the maximum tensile stress theory. Theory is said to predict the "limit of viscoelastic action," assumed to coincide with "large-scale cracking" and said to be well defined in experiments, but "cannot be used for the precise assessment of the ultimate load." Various interaction-type formulas are derived for such members, with and without prestress. The main practical conclusion is that a limited amount of bending increases torsional resistance sizably, while a limited amount of twisting decreases bending resistance only insignificantly. It is therefore proposed that members subject to bending plus torsion be dimensioned separately for these two actions, without regard to interaction.

Reviewer believes results of this theoretical investigation are likely to be correct qualitatively but in need of quantitative confirmation by test, in view of uncertainty of strength-theory assumptions. Such test evidence is promised in a subsequent paper. G. Winter, USA

3556. Habel, A., and Zacher, W., Secondary stresses in wooden trusses (in German), *Bautechnik* **31,** 1, 13–19, Jan. 1954.

Studying three examples of nailed or bolted wooden trusses, authors analyze the influences on the values of stresses of continuity of chords, of the rigidity of joints of vertical members to chords, and of eccentricity of bars with respect to joints.

Except for the last-mentioned influence, calculations made in the usual way (supposing pin joints) give dimensions for the different members that must not be modified as a consequence of this more accurate investigation. In the case of bars eccentrically joined to joints, practical rules are given to reinforce the trusses where they appear to be weak according to exact calculation.

It is very interesting to compare the diagrams obtained for different suppositions of joints among bars, which are included in the work. Reviewer wishes to point out that this study is based on the differences between two calculations, for one of which fewer simplifications are admitted than for the other. It is, therefore, important to verify experimentally the behavior of the trusses studied analytically. A. J. Bignoli, Argentina

3557. Petur, A., and Kurutz, I., Design of wooden beams subjected to bending, with regard to the elastic properties of wood, *Acta Techn. Hung. Budapest* **7,** 3–4, 257–274, 1953.

Problem of bending of wooden beams is treated by recognizing the nonlinear elastic stress-strain properties and unsymmetrical strength properties in tension and compression. A semiempirical design chart is presented for prediction of the failure moment of a beam of solid or flanged section, based on the ratio of tensile to compressive strength of the material.

An approach of this type is more rational than conventional modulus-of-rupture and form-factor method, appears to be easier to apply, and limited experimental data indicate better accuracy. P. E. Sandorff, USA

3558. **Birkenmaier, M., Prestressed rock anchors** (in German) *Schweiz. Bauzt.* **71**, 47, 688–692, Nov. 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3491, 3511, 3583, 3595, 3752)

3559. **Seiler, J. A., and Symonds, P. S., Plastic deformation in beams under distributed dynamic loads,** *J. appl. Phys.* **25**, 5, 556–563, May 1954.

In a previous paper [AMR **6**, Rev. 1531] Symonds and Lee discussed the plastic deformation of a free-free beam subjected to a concentrated central impact load, assumed in the form of a rectangular pulse, under the assumptions of perfect plasticity and neglect of elastic strains. Later [AMR 7, Rev. 1789], Symonds analyzed the effect of a variation of the nature of the force pulse. The present paper is concerned with distributed load, applied as a rectangular pulse. The total load P is applied over a finite portion $2kl$ of the beam, where $2l$ is the total length. Qualitative and quantitative results are obtained for representative values of k and $\mu = P/M_0$, where M_0 is the yield moment. It is found that for $k \leq 0.361$ the qualitative description follows that of concentrated load ($k = 0$), while for $k > 0.361$, the yield hinges form somewhat differently. However, the final central angle of deformation is considerably less for even a small value of k, particularly when μ is large. For example, with $\mu = 40$, an increase in k from 0 to 0.05 gives a decrease of 25% in the final central angle. Since a true concentrated load is a physical impossibility, this indicates that experimental values may be lower than theoretical ones.

As authors mention, effects of strain hardening and more realistic force pulses would probably decrease this difference. An alternative measure of the deformation would be the final transverse displacement of the center relative to the ends. Authors do not compute this, but presumably it would be less sensitive to distribution of load. P. G. Hodge, Jr., USA

3560. **Lee, E. H., and Tupper, S. J., Analysis of plastic deformation in a steel cylinder striking a rigid target,** *J. appl. Mech.* 21, 1, 63–70, Mar. 1954.

See AMR **7**, Rev. 1093.

3561. **Onat, E. T., and Prager, W., The necking of a tension specimen in plane plastic flow,** *J. appl. Phys.* **25**, 4, 491–493, Apr. 1954.

Paper treats title problem by linearization of the yield condition and of the flow rule, using an assumption that actual solution differs from a stated (reasonable) form by first-order terms. Neglecting higher-order terms, consequent analysis is simple and the results appear convincing. D. N. de G. Allen, England

3562. **Craggs, J. W., Characteristic surfaces in ideal plasticity in three dimensions,** *Quart. J. Mech. appl. Math.* **7**, part 1, 35–39, Mar. 1954.

As used in this paper, the term "characteristic surfaces" covers surfaces of strong discontinuity (singular surfaces) as well as the surfaces of weak discontinuity for which this term is usually reserved. It is shown that the determinant of the stress deviation must vanish at every point of a characteristic surface. (The same result was obtained by T. Y. Thomas [AMR **5**, Rev. 2825; 7, Rev. 780].) Special cases in which this condition is fulfilled are listed. (To this list the following cases should be added: Torsion of prismatic or cylindrical bars, torsion of a shaft of varying diameter, Freiberger's torsion of a circular ring sector, Rep. SM 213, Aero. Res. Labs. Australia, 1953.) An example of a velocity discontinuity in an axially symmetric field of flow is constructed. W. Prager, USA

3563. **Bueche, F., The viscoelastic properties of plastics,** *J. chem. Phys.* **22**, 4, 603–609, Apr. 1954.

The theory of viscoelasticity of soft solid and liquid polymers is developed with a molecular model of a three-dimensional zigzag of masses connected by springs and surrounded by a viscous medium. The springs have the elastic properties of the strands of a rubberlike network. The motion of the molecule is the superposition of a series of modes represented by normal coordinates, each associated with a relaxation time. The method is applied to the following systems and time-dependent loading patterns: (a) Constant force applied to network polymer, steady-state solution; (b) sinusoidal force on network polymer; (c) creep under constant load, linear polymer; (d) stress relaxation, linear polymer; (e) sinusoidal force, dilute polymer solution; (f) sinusoidal force, linear polymer. The predicted functions of time and frequency have the general form observed experimentally. J. D. Ferry, USA

3564. **Grunzweig, J., Longman, I. M., and Petch, N. J., Calculations and measurements on wedge-indentation,** *J. Mech. Phys. Solids* **2**, 2, 81–86, Jan. 1954.

Indentation of lead (60% strained to decrease strain-hardening rate and with 0.05% Te or 2.5% Ag to suppress recovery at room temperature) is investigated by steel wedges with wedge angles up to 60°. Various coefficients of friction are obtained with dry (frictional stress = shear yield stress), lubricated ($\mu = 0.09$), and lubricated and to-and-fro-moved ($\mu = 0$) wedges. Comparison of results with those by theory of Hill, Lee, and Tupper [*Proc. roy. Soc.* (*A*) **188**, 273, 1947] shows fair agreement, observed penetrations for given loads are somewhat higher than theoretical values, the more the higher the wedge angle (up to 10–25%). Observed ratio contact length to penetration values is in a similar manner lower than theoretical values. Some measurements are made with polytetrafluoroethylene (Fluon).

A. Kochendörfer, Germany

3565. **Sautter, W., Kochendörfer, A., and Dehlinger, U., Regularities in plastic deformations of metals under multiaxial loads. I, II** (in German), *Z. Metallk.* **44**, 10, 12; 442–449, 553–565, Oct., Dec. 1953.

The first part reviews stress-strain laws for perfectly plastic and work-hardening materials; the second part reports on combined tension and torsion tests on thin-walled aluminum tubes. Isotropy and the practical absence of plastic volume changes and viscosity effects were verified by means of constant stress-ratio tests. To provide experimental evidence in favor of either the incremental or the total strain theory, tests of the type suggested by Reuss [*ZAMM* **10**, 266, 1930] and first used by Hohenemser and Prager [ibid. **11**, 15, 1931; **12**, 1, 1932] were carried out. In these tests the thin-walled tube is brought to the yield limit in tension and then twisted while the extension is held constant, or brought to the yield limit in torsion and then pulled while the twist is held constant. The strains predicted by the incremental theory agreed with the observed strains to within ±3%, whereas the strains predicted by the total strain theory exceeded the observed strains by amounts up to 900%. Small oscillations of the stress path around a smooth curve had no appreciable effect on the plastic strain. The plastic work performed in reaching a certain state of stress was independent of the stress path leading to this state. The isotropic incremental theory used was adequate as long as the effective extension did not exceed 10% and

the test did not involve a rotation of the principal axes of stress by more than 45°. Beyond these limits anisotropy effects become appreciable. It is stated that these effects are responsible for some discrepancies between the experimental results of Taylor and Quinney [*Phil. Trans. roy. Soc.* (*A*) **230,** 323, 1931] and the present tests. W. Prager, USA

3566. Ketter, R. L., Kaminsky, E. L., and Beedle, L. S., Plastic deformation of wide-flange beam-columns, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 330, 53 pp., Nov. 1953.

Paper presents a method for determining the influence of axial load on the moment-curvature relationship in the plastic range neglecting strain hardening. To bring theory into closer agreement with as-delivered steel W F sections, effect of an assumed residual stress distribution is considered. Buckling loads for eccentrically loaded steel W F columns are computed, and derived moment-curvature relationships are applied to find column end rotations and deflection at midheight. Tests carried out on two sizes of W F shapes indicated fair agreement with theory. In most cases, theory appears to represent an upper bound. Authors find that the reduction in collapse strength due to residual stress at $L/r = 85$ ranges from 22% for zero eccentricity to about 4% for $ec/r^2 = 1.0$ for strong axis buckling, with comparable values for weak axis buckling. Authors conclude that initial yield solution (secant formula) is generally on the unsafe side for intermediate columns with small eccentricities and is too conservative for short columns. K. S. Pister, USA

3567. Lin, T. H., Stresses in columns with time dependent elasticity, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 196–199, Apr. 1953.

Paper shows a method of calculating stresses and deflections of columns of small initial curvature, with time-dependent elasticity. The creep behavior of a number of materials at a particular temperature, with small variation of stress, can be approximately represented by the use of mechanical models with springs and dampers. The Maxwell-Kelvin model is used with the constants determined from empirical data. The initial curvature is expressed in sine series. The differential equation of equilibrium is solved by Laplace transformation. The deflection-time curve is obtained and hence the stresses are known. A numerical illustrative example is given and comparison is made with the experimental data.

From author's summary by J. Heyman, England

Failure, Mechanics of Solid State

(See also Revs. 3577, 3753, 3779)

3568. Wilson, A. H., The theory of metals, 2nd ed., New York, Cambridge University Press, 1953, viii + 346 pp. $8.50.

A second and completely revised edition of the well-known work published in 1936. The vast amount of research, both experimental and theoretical, since the publication of the first edition (and the publication of other important works in this field, such as Mott, and Jones and Seitz) makes this a most welcome edition to the library of physicists, metallurgists, and engineers. The format and the order of the chapters are to be commended; both are superior to those of the older edition. The author is quick to point out that the agreement between theory and experiment is all too often far from adequate. However, the difficulties are essentially mathematical ones due to the complexity of the problems which must be solved. After a historical introduction, which treats the Drude and Lorentz theories and leads to the Sommerfeld theory, Wilson discusses the motion of an electron in a perfect crystal lattice (chap. 2) and introduces the energy band concept. The following chapters (3–5) are devoted to the structures of metals, alloys, and semiconductors. Chapters 6–8 are devoted to the properties of thermal, magnetic, and electrical properties of metals, chap. 7 being devoted to ferromagnetism. Surface effects are not discussed and, in consequence, the chapters on superconductivity and optical effects, included in the first edition, are omitted here. The last two chapters are of extreme importance. The first of these treats the mechanism of conductivity (the interaction between lattice vibrations and electrons), and the results are considered in terms of the more recent experimental evidence. The last chapter treats the application of variational principles to conduction phenomena. Variational principles offer a more powerful tool for the solution of the integral equations which express the conductivity and may be the means of finding if the inadequacies of the theory are purely mathematical or if new physical principles are involved. The appendix, devoted largely to the Fermi-Dirac statistics, is an excellent source of ready information on the Fermi-Dirac integrals. This is not a book to be perused; it is one which should be digested or at least be consulted often by the research worker. E. Koenigsberg, USA

3569. Work, C. E., and Dolan, T. J., The influence of temperature and rate of strain on the properties of metals in torsion, *Univ. Ill. Engng. Exp. Sta. Bull.* 51, 24, series no. 420, 109 pp., Nov. 1953.

An experimental study was made in order to determine the effect of temperature and rate of strain on the strength, ductility, and energy-absorbing capacity of seven different structural metals in torsion. Cylindrical specimens 0.25 in. in diam were tested at four different constant strain rates from 0.0001 in./in./sec to 12.5 in./in./sec and at four different temperatures from room temperature up to 1200 F.

Torque, angle of twist, and time were continuously recorded and the torsional properties determined. The detail results are presented in three-dimensional charts and analyzed in terms of the mechanisms altering the material behavior. In general, it was found that an increase in strain rate caused an increase in strength, whereas an increase in temperature reduced the strength of all metals except in the blue-brittle temperature range for steel. Extremely great ductility was exhibited by some of the metals at the highest elevated temperatures employed, particularly at the slower rates of straining.

The experimental observations are compared with several theories that have been proposed to express mathematically the effects of strain rate and temperature on mechanical properties.

From authors' summary by M. J. Manjoine, USA

3570. Hodge, P. G., Jr., The effect of strain hardening in an annular slab, *J. appl. Mech.* **20,** 4, 530–536, Dec. 1953.

The problem considered is the determination of the stresses and strains in a circular slab with a cutout, subject to uniform biaxial tension. The material is assumed to be elastic until a maximum shear stress yield criterion is reached. In the plastic range, it is assumed to satisfy a flow law which is also based on the maximum shear stress. The stress-strain curve in tension is represented by a number of straight-line segments, the rate of strain hardening being different for each segment. The material is incompressible for both the elastic and plastic ranges.

If the thickness of the slab is assumed to be constant (so that the incompressibility condition is violated), and if the displacements are assumed to be small (so that the initial dimensions of the slab can be used), elastic-plastic solutions for several interesting variations of strain hardening can be obtained. For the fully

plastic solution, the strains are considered to be large so that the elastic deformations can be neglected.

Results of numerical computations are given for strain-hardening and nonstrain-hardening slabs. Y. H. Pao, USA

3571. **Dieter, G. E., Horne, G. T., and Mehl, R. F., Statistical study of overstressing in steel,** *NACA TN* 3211, 34 pp., Apr. 1954.

Effect of microstructure of 4340 steel on susceptibility to reduction in fatigue life due to cycles of overstress was investigated. When tested at equivalent percentage of stress, a quenched and spheroidized structure was more susceptible to fatigue damage than a quenched and tempered structure.

Effect of overstress on endurance-limit statistics was studied for the quenched and spheroidized structure. Enough specimens were tested to determine the endurance-limit statistics by the probit method. The decrease in the mean endurance limit due to cycles of overstressing was much greater than would be expected from nonstatistical investigations which are reported in the literature. The effect is interpreted as support for the belief that the bulk of the fatigue damage takes place before the first 30% of the total fatigue life.

From authors' summary by G. V. Smith, USA

3572. **Zinsser, R., The time-yield of steel wires stressed within the range of fatigue under pulsating tensile stresses** (in German), *Stahl u. Eisen* **3**, 74, 145–151, Jan. 1954.

3573. **Schott, G. J., The statistical significance of a few fatigue results,** *Nat. aero. Establ. Canad.* LR-58, 27 pp., May 1953.

Material Test Techniques

(See also Revs. 3532, 3554, 3582, 3584)

3574. **Wright, P. J. F., Statistical methods in concrete research,** *Mag. Concr. Res.* no. 15, 139–149, Mar. 1954.

Paper aims to bring to the attention of research workers certain statistical methods which have been helpful in planning and interpreting concrete research. The evaluation of variation in test results is discussed and some useful statistical processes are introduced. These include a test for the significance of the difference between two sets of results, method of analyzing causes of variation in test data, fitting of equations to experimental relationships between variables, and method for fitting a Gaussian distribution to test results.

From author's summary by J. E. Goldberg, USA

3575. **Nielsen, K. E. C., Effect of various factors on the flexural strength of concrete test beams,** *Mag. Concr. Res.* no. 15, 105–114, Mar. 1954.

Paper describes bend tests on plain concrete beams. The test results are here used as a basis for an analysis of the effect of various factors on the flexural strength of concrete test beams. The reported results of previous workers in this field are summarized and discussed. These are so presented as to provide additional data for an analysis of the applicability of various theories of the effect of dimensions of the test specimen. Paper closes with some practical considerations which should be taken into account when determining the flexural strength of plain concrete beams. From author's summary by R. G. Boiten, Holland

3576. **Ashton, L. A., Comparative tests on prestressed and reinforced concrete floors during and after fires,** *Civ. Engng. Lond.* 48, 569, 1035–1038, Nov. 1953.

3577. **Hardrath, H. F., and Illg, W., Fatigue tests at stresses producing failure in 2 to 10,000 cycles; 24S-T3 and 75S-T6 aluminum-alloy sheet specimens with a theoretical stress-concentration factor of 4.0 subjected to completely reversed axial load,** *NACA TN* 3132, 14 pp., Jan. 1954.

Results indicate that failure can occur in much smaller number of cycles than might be inferred from previously published data for unnotched specimens. Failures occurred in less than 50 cycles at two thirds of static tensile strength and in as few as two cycles when applied load was near static ultimate. *S-N* curves were concave upward for almost complete range of life; reversal in curvature occurred at approximately 10 cycles. Test techniques and special apparatus also are described.

G. M. Sinclair, USA

3578. **Deryagin, B. V., Ratner, S. B., and Futran, M. F., Investigation of the interrelations between frictional and adhesive forces by the method of crossed fibers,** *Nat. Sci. Found.* tr-228, Feb. 1954; *Dokladi Akad. Nauk SSSR (N.S.)* **92**, 6, 1137–(1140), Oct. 1953.

Experiments were made in order to investigate if, following authors' theory of external friction published in 1934 to which reference is made, the force of friction F is proportional not to the load, according to Amonton's law, but to the sum of the load N and of the attractive force N_0 between the bodies in contact.

To solve the problem, friction was measured between two fibers crossed at right angle which were at first brought in contact (the force is then assumed to be the adhesion force N_0) and then pressed against each other with variable force, including negative values of N. N and F were determined by a microscope measuring the deflection of one of the two fibers.

The materials used were freshly drawn quartz fibers and also fibers whose surfaces (one or both) were covered with thin films of natural rubber. Special care was taken to avoid air currents, vibration effects, and to remove electrical charges. F/N_0 are plotted against N/N_0.

Some unexpected data are obtained in the region of negative values of N. In the positive region, results confirm the expected law. Author explains the difference in the relationships between F and N for $N > 0$ and $N < 0$ by the observation that, in the region of negative values, the overcoming of static friction is always accompanied by the breaking away of mutual contact of the fibers. D. De Meulemeester, Belgium

Mechanical Properties of Specific Materials

(See also Revs. 3491, 3535, 3557, 3563, 3569, 3571, 3574, 3593, 3728)

3579. **Bickel, E., Metals in machine design [Die metallischen Werkstoffe des Maschinenbaues],** Berlin, Springer-Verlag, 1953, x + 442 pp., 456 figs. DM 37.50.

This textbook serves as an introduction to metallurgy of materials in machine design. The first three chapters contain information on crystal structures, principles of alloying, and physical and chemical properties of the materials, while the fourth and final chapter describes the use and properties of ferrous and nonferrous metals. Topics discussed include eutectics, phase diagrams, principles of alloying, x-ray methods, heat treatment, hardness, stress concentration, fatigue, impact, wear, and electrical and magnetic properties. Text is concluded with a discussion of aluminum and magnesium alloys, bearing metals, and materials for cutting tools. While the omission of references to the literature resulted in a less well-rounded text, nevertheless

the author is to be commended for the well-written and well-arranged presentation of the subject. J. Frisch, USA

3580. Jasnogorodski, I. S., Electrolytic hardening [Elektrolytisches Härten] (translated from Russian), Berlin, Verlag Technik, 1951, 119 pp. DM 13.

This small book describes a method of heat treatment that is, so far as this reviewer could determine in a brief survey, virtually unknown on this side of the Iron Curtain. Yet the process, in view of its apparent simplicity, inexpensiveness, and convenience certainly merits evaluation by western technology.

Electrolytic hardening, as the method is called, is based on the fact that the surface of the cathode in an aqueous electrolytic cell is heated at a rate strongly dependent on the d-c voltage impressed across the cell. The heating can become quite intense within the region immediately surrounding the cathode, yet the remainder of the solution is relatively undisturbed. For example, this reviewer has witnessed a crude experiment in which the end of a $^1/_4$-in. steel drill rod serving as the cathode was melted away when about 15 amperes at 220 volts was passed through a sodium carbonate solution for 10 sec or so. Except for the drill rod, the cell underwent little apparent change.

Although this heating effect is more or less familiar to many in the technical field, it has apparently never been extensively utilized for heat treatment. Yet the possibilities of such application are many. By controlling current density, heating time, solution composition, and cell geometry, and by using the surrounding solution for quenching, steel could be surface- or deep-hardened in the absence of air with little expense and at high speed. To his credit, Jasnogorodski has recognized these possibilities and pursued them with obvious diligence. He describes the heating effect and the factors controlling it, techniques for heating the ends or general surfaces of workpieces, the use of suitably placed insulators to localize the heating, safety practice, automatic machinery for electrolytic hardening, and many other things. For his efforts he was awarded a Stalin prize in 1947.

The book unfortunately possesses several drawbacks that may hinder its effective use for publicizing electrolytic hardening. It is published in East Germany and thus may not be readily accessible to western readers. Printed in German, it would in any event reach a rather limited American audience. An editor has inserted a foreword that is unadulterated propaganda: such phrases as "the dialectic-materialistic character of the conformity to law underlying the science of metallurgy and heat treatment" and "the notorious American practice" are apt to predispose the western reader toward using the main part of the book more for amusement than for technical instruction. Happily, the technical bulk of the book is free of propaganda.

The book itself possesses several minor defects. The printing, particularly the illustrations, is crude. An index would be helpful. In attempting to explain the phenomenon on which electrolytic hardening is based, the author raises more questions than he settles, from a scientific point of view.

Nevertheless, one hopes that the book, or better a translation of it, will soon receive wider attention than has already been the case. The techniques of electrolytic hardening certainly deserve a close look and evaluation in the West. J. G. Leschen, USA

3581. Goodman, S., and Russell, S. B., Poisson's ratio of aircraft sheet materials for large strains, Proc. First. Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 1–4, Apr. 1953.

Paper reports results of experimental investigation of relations between lateral contraction and axial elongation in sheet metal under simple tension. Principal object of study is Poisson's ratio in plane of sheet, defined by $\nu = e_t/e_a$, where e_t and e_a are strains in transverse and axial directions, respectively, measured over 1.5-in. gage lengths. Above elastic range, ν increased to a maximum (although for one magnesium alloy it decreased sharply at first), then decreased slowly or remained constant. Representative maximum values obtained include 0.434 for an alclad aluminum alloy, 0.622 for a magnesium alloy, and 0.769 for commercially pure titanium.

For an isotropic material, Poisson's ratio approaches 0.5 as a limit. High values observed are due to anisotropy of rolled sheets, for which ratios measured in width and thickness directions differ markedly. Where latter was observed, it was found to be less than 0.5 and decreased with increasing strain. Relation between Poisson's ratio in the two directions can be computed for any inelastic axial strain, assuming no plastic dilatation, from expression $1 + \delta = (1 + e_a)(1 + \nu_{th}e_a)(1 + \nu e_a)$ in which ν_{th} is for the thickness direction and δ is elastic dilatation. Values of ν computed from measured values of ν_{th} were found to be in good agreement with observed values of ν for large strains. Additional check on assumption of no plastic dilatation was made by density measurements of strained and unstrained metal.

Effects of orientation of specimens with reference to direction of rolling were observed, as well as effect of sheet thickness.

Report covers tests of 121 specimens and includes interesting details on instrumentation for measuring plastic strains. Additional details are given in references. C. W. Richards, USA

3582. Gibson, J., The behaviour of metals under tensile loads of short duration, *Instn. mech. Engrs. Proc. (B)* **1B,** 11, 536–550, 2 plates, 1952/1953.

Forced-time and extension-time curves for steels, steel castings, cast iron, bronze, brass, and aluminum alloys were measured under impact loading up to about 10 millisec. While forces are measured by strain gages upon the gripping heads, elongation is measured by a constantan wire between the heads which is used as a strain gage. Metals without a sharp yield point in statical loading also had a smooth curve under impact loading. Aluminum alloys, brass, and one of the steels with high ultimate stress showed almost the same 0.1-proof stress in impact test as in statical tests, bronze, cast iron, and the other steel having increased proof stresses up to 19%. Steels and steel castings with a sharp yield point had an elevation of the yield point of 13 to 30%. While the elongation in the metals with a smooth curve was uniform, steels with a sharp yield point were elongated only in a short section forming Lüders lines. There was a delay of yielding between the elastic elongation and the beginning of yielding. For several blows, elongation is spread all over the specimen similar to the statical test. Local elongation at first blow was found up to 3%. Also, in yielding stress was increased to the statical curve.

In some other tests delay time was changed and the results were compared with the theories of dislocations of Cottrell and others. A. Krisch, Germany

3583. Chang, H. C., and Grant, N. J., Mechanism of creep deformation in high-purity aluminium at high temperatures, *J. Inst. Metals* 82, 229–235, 5 plates, 1953–1954.

Creep of very coarse-grained high-purity aluminum was studied at 400, 700, and 1100 F over a stress range from 50 to 1200 psi. Simultaneous observations and measurements of localized strains on polished specimen surfaces were made by means of a high-temperature microscope. The sequence of the development of various deformation modes, heavy slip bands, kink bands, and subgrains, was followed. Slip is the fundamental mechanism of deformation for both single-crystal and polycrystalline materials even in high-temperature creep. Component creep curves (measured between two closely spaced

markings) obtained across grain-boundary-affected slip bands show a periodic behavior, the significance of which is discussed. Subgrains are shown to be formed under conditions where slip development is restricted. Two types of subgrains, one caused by deformation bands and the other by kinking bands, are observed and discussed. From authors' summary

3584. **Rondeel, J. H., Kruithof, R., and Plantema, F. J., Comparative fatigue tests with 24 S-T Alclad riveted and bonded stiffened panels,** *Nat LuchtLab. Amsterdam Rap.* S.416, 14 pp., 1953.

The purpose of the investigation was to compare the fatigue strengths of bonded and riveted flat sheet-stringer panels of identical construction except for the sheet-stringer joints. The results of fatigue tests on panels stiffened with angle section stringers and top-hat stringers are given. The bonded panels proved to be superior both in static strength and in fatigue strength and showed no dangerous propagation of damages.

From authors' summary

3585. **Schmidt, W., and Hogan, W. E., Industrial hard-chromium plating,** *Mech. Engng., N. Y.* **76,** 3, 248–254, Mar. 1954.

3586. **King, R. F., and Tabor, D., The strength properties and frictional behavior of brittle solids,** *Proc. roy. Soc. Lond.* (A) **223,** 1153, 225–238, 4 plates, Apr. 1954.

An experimental study has been made of the friction and strength properties of crystalline materials such as rock salt, lead sulphide, and ice. From frictional measurements on rock salt and from estimates of the real area of contact during sliding, the specific shear strength of the material at the rubbing interface is calculated and found to be nearly seven times as great as the bulk shear strength of a rock-salt single crystal. It is suggested that this is because the material in the region of contact is under very high hydrostatic pressures. Independent compression experiments of rock-salt crystals confirm this. Under high hydrostatic pressures brittle fracture is prevented, marked plastic deformation occurs, and the plastic yield stress reaches values very much greater than the bulk shear strength of an uncompressed specimen. As with metals, the plastic yield stress of rock salt may be correlated with its indentation hardness. Experiments also show that, if two rock-salt specimens are pressed together between rigid anvils so that there is appreciable plastic flow, marked adhesion occurs between the crystals and the interface is almost as strong as a single crystal. In addition, hardness measurements of the track formed during sliding show that, although there is some cracking and surface fragmentation, the behavior is dominated by plastic deformation of the surface layers. These results and similar ones obtained with other brittle materials suggest that the frictional behavior of brittle solids is primarily due, as with metals, to local plastic flow and to strong interfacial adhesion at the regions of real contact. From authors' summary

3587. **Goebel, E., The action of frost on pit lime** (in German), *Zement-Kalk-Gips* **42,** 7, 252–254, July 1953.

An influence on the surface of pit lime is exerted by the action of frost. This is due to an increased formation of carbonate. The penetration depth is about 12 cm for lime having been stored in a pit for a 2-months' period of freezing and thawing. The strength tests carried out on mortar showed no disadvantageous values. The constancy of volume remained likewise unaffected. By treating pit lime mechanically after thawing, its original structure may be regained almost completely.

D. Krsmanović, Yugoslavia

3588. **Hamman, H., On the compression strength of light-weight concrete** (in German), *Zement-Kalk-Gips* **6,** 7, 237–244, July 1953.

Paper deals mainly with lightweight concrete made of pumice, both natural and artificial. After listing the various testing methods prescribed in Germany, author states that, contrary to ordinary concrete, strength increases with size of specimen. The difference in the strength behavior of T-blocks and other shapes as compared with cubes is then discussed. The influence of the following factors on strength is illustrated by tables and diagrams: grading, size, shape, surface, and strength of aggregates, compaction, etc. H. Craemer, Germany-Pakistan

3589. **Tikhonov, V. A., Effect of plasticizing and air-retaining admixtures on the heat emission and other properties of cement** (in Russian), *Gidrotekh. Stroit.* **22,** 7, 19–22, July 1953.

3590. **van Langendonck, T., Resistance of partially loaded concrete and mortar blocks** (in Portuguese), *Engenharia* no. 115, 8 pp., Mar. 1952.

Mechanics of Forming and Cutting

(See also Revs. 3508, 3585)

3591. **Sieker, K.-H., and Rabe, K., Design of small parts and assemblies from the viewpoint of manufacturing technique and materials selection [Fertigungs- und stoffgerechtes Gestalten in der Feinwerktechnik]** (Konstruktionsbücher Bd. 13), Berlin, Springer-Verlag, 1954, v + 166 pp., 493 figs. DM 21.

Book represents a well-organized review of methods and materials employed in the production of components of watches, measuring instruments, typewriters, telecommunication equipment, and the like.

The main body consists of two parts dealing with metallic (101 pp.) and nonmetallic (39 pp.) products, respectively. Of these, part 1 contains chapters dealing with machined, press-formed (stamped, cold-extruded), cast, and sintered elements. Part 2 deals with laminated and molded plastics, and with ceramic materials. The remaining pages include an introduction and a final chapter showing examples of complete multicomponent products.

Each chapter is divided into four sections describing the particular manufacturing process, materials used, design principles, and methods of rational assembling and joining the individual elements. In some cases there is an additional section discussing strength requirements and calculations.

The authors' main object was to present in a systematic but concise form a very considerable amount of specialized information scattered through various periodicals, specifications, and textbooks. The reviewer believes that, in the main, this aim has been achieved with a remarkable success, the numerous effective and well-chosen illustrations being very instrumental in this respect. Perhaps the section devoted to powder metallurgy products is the weakest point of the work; this technique is much too important in the field under consideration to be dismissed on only six pages.

This book may be recommended especially to the junior design personnel in various branches of the precision-mechanics industry. However, even the senior man is likely to find it interesting and useful in many respects. N. H. Polakowski, USA

3592. **Whyte, M., Statistical control in metal-working operations,** *J. Inst. Metals* **82,** 334–344, 1953–1954.

In many metal-working processes, a quantitative assessment of

variability can be used to gain efficiency without fundamental changes to the processes. Statistical aspects of sampling are discussed, and it is shown that sampling rates should be fixed in relation to the quality and homogeneity of the material being tested. Wherever possible, material processed as a batch should be the unit which is sampled.

The selection, control, and sensitivity of routine tests are considered. The cost of a few relatively expensive tests of high reproducibility is compared with that of a larger number of cheaper tests of low reproducibility. For equal confidence in the final test result, the less reproducible test tends to be the cheaper where the variability in the material being tested is high and if the greater number of tests which are required can be spread over a wide range of samples. Statistical quality control provides a means of insuring the continuing reliability of routine tests.

The value of error-actuated control throughout an entire production process is emphasized. Statistical methods may be used to assess limits for intermediate variables and qualities which will serve as criteria for the early rejection of material which would finally prove substandard. Statistical quality control provides a sound basis for efficient process control at all stages.

A number of applications to specific problems arising in metalworking operations are described. A brief summary of the simpler statistical concepts and formulas is given in an appendix.

From author's summary

3593. Wolfe, K. J. B., Recent developments in the machinability of steel, *Instn. mech. Engrs. Proc. (B)* **1B,** 11, 517–527, 8 plates, 1952/1953.

A description of the term machinability is given, and it is shown that the behavior of the metal being machined, called "true machinability," and also the conduct of the tool, known as "cutability," are separate and distinct factors in the metal-cutting process. The action of cutting fluids is shown to be a modifying factor.

Recent work at one laboratory in the field of true machinability is described and includes the effects on this property of hardness, rate of work hardening, microstructure, manganese segregations, and the size of lead globules. The effects on surface finish of speed in turning and some aspects of interest which arise under conditions of intermittent cutting, such as shaping, are included.

Under new work on cutability is mentioned the modifying effect on that factor of surface austenite, produced by grinding, and metallic segregations, as shown by microradiography. A general description is given of the properties and performance of milling cutters produced by a casting process. Developments in the field of cutting fluids are noted.

From author's summary by L. V. Colwell, USA

3594. Druzhinskii, I. A., Analyzing the possibility of profiling with mechanical control (in Russian), *Stanki i Instrum.* **24,** 6, 5–9, June 1953.

3595. Gubkin, S. I., Small-scale study of high-temperature high-velocity processes for deforming metals by pressure (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 4, 533–542, Apr. 1953.

A polemical paper. A. A. Il'yushin [AMR 6, Rev. 1637] holds that under the title conditions it is possible to disregard the effect of deformation velocity on the strength of materials, since its increase by two to four orders of magnitude raises the resistance to deformation only slightly. He omits from consideration the effect of speed on the coefficient of friction. The paper refutes these contentions in the light of previously published data.

J. D. Gat, USA

3596. Frisch, J., and Thomsen, E. G., An experimental study of metal extrusions at various strain rates, *Trans. ASME* **76,** 4, 599–606, May 1954.

See AMR **7,** Rev. 1508.

3597. Siebel, E., The stripper pressure in deep drawing (in German), *Stahl u. Eisen* **3,** 74, 155–158, Jan. 1954.

3598. Göhre, E., Increasing production and decreasing waste in pressworking of metals [Leistungssteigerung und Ausschussminderung in der Stanzerei], München, Carl Hanser Verlag, 1953, 136 pp., 154 figs., 66 tables. DM 13.50.

Practical aspect of pressworking is treated and book may be of value to production engineer, foreman, and technician associated with pressworkings processes and machinery. Six chapters deal with the care and maintenance of presses; handling of tools; reduction of waste through proper selection of forming operations; deep drawing; simple, economic, and safe devices to increase production; and management rules to increase production. Set of rules for the press operator and for plant organization is included. Recommendations for tolerances and techniques to be employed in various pressworking operations are given. The theoretical phase of pressworking is not treated.

D. Kececioglu, USA

3599. Molina, M. H., Cutting and punching tools in press work (in Portuguese), *Anales Mec. Electr.* **30,** 4, 192–201, July–Aug. 1953.

Author presents a study and a classification of different types of punching and cutting tools for use in presswork, their advantages and limitations. He gives rules for their selection based on punch characteristics and number of parts to be produced. Structural and operating characteristics of various types of presses and their effects on punch and die design are examined. The subject matter is illustrated by examples; formulas are given for load and energy required in punching operations, with constant factors for different punch design, kind and thickness of material to be punched.

M. Martellotti, USA

3600. Geleji, A., Calculation of efforts and power demand in the Ehrhardt process of making seamless pipe (in German), *Acta Techn. Hung. Budapest* **7,** 3/4, 477–505, 1953.

The basic principle involved is one of indirect extrusion of a square billet of such size that it will slip into the round extrusion cylinder and will completely fill the space in the cylinder when the extrusion mandrel is forced into it. The force initially required to push the mandrel into the billet is calculated on the basis that the mandrel pressure is equal to the flow strength of the material. Subsequent reduction is obtained by rolling with the mandrel in place, or by drawing, in which the mandrel forces the extruded bloom through a series of dies.

The forces involved in these subsequent operations are calculated as a series of steps based on a consideration of three-dimensional states of stress in the material as it passes through the rolls or dies. The conditions of flow are based on a constant flow stress k_f.

The total work calculated includes the work of deformation, the friction energy loss in the die, and the friction energy loss in slippage on the mandrel.

R. G. Sturm, USA

3601. Cleghorn, G., and Burnell, I. H., The manufacture of crankshafts by the continuous grain flow process, *Trans. Inst. mar. Engrs.* **65,** 3, 49–64, Mar. 1954.

Paper describes a method of manufacturing crankshafts from bar material in a specially designed machine adapted for use under a

forging press. A comparison is made between the usual method of forging crankshafts and the continuous grain flow method.

From authors' summary

3602. Lewis, D. M., Techniques for the investigation of thermal conditions in continuous casting, *J. Inst. Metals* **82,** 395–413, 3 plates, 1953–1954.

Systematic studies in continuous casting are lacking and present paper is a first attempt in filling that gap. Procedure is in part experimental, using thermocouples in the stream of solidifying metal, and in part mathematical, using a steady-state analog computer (electrolytic-tank type) and iteration methods. In both instances the mathematics is based on a sweeping assumption of disregarding heat transport by moving metal and assuming instead a steady-state condition with no heat sources. These assumptions are not stated explicitly. Experimental techniques include a number of clever procedures. For example, since the metal moves it is necessary to disconnect the thermocouple as the ingot moves on. This is done by introducing fusible links. The electrical equipment for recording rapidly changing temperatures is described only briefly, with a more detailed paper promised.

V. Paschkis, USA

Hydraulics; Cavitation; Transport

(See also Revs. 3617, 3618, 3701, 3703, 3777)

3603. Vennard, J. K., Elementary fluid mechanics, 3rd ed., New York, John Wiley & Sons, Inc., London, Chapman & Hall, Ltd., 1954, xii + 401 pp. $5.50.

This is the third edition of the splendid text on fluid mechanics intended for use at the junior level and suitable in either a civil or aeronautical curriculum.

Generally, the book is the same as the earlier editions; however, much of the text has been rewritten, many of the tables have been expanded, and additional material on compressible-flow theory has been included.

Specifically, the book is composed of twelve chapters dealing with such topics as the usual fundamentals, statics of fluids, one-dimensional flow, incompressible and compressible-flow theory, impulse and momentum principles, flow in pipes, flow around immersed bodies, flow in open channels, and methods on fluid measurements. This material is, for the greater part, well written, concise, and clear.

Perhaps the greatest unfavorable criticism that can be made concerns the statement that no previous knowledge of thermodynamics is necessary for the student using the text. It is thereby difficult to see how the material on compressible flow of fluids is justified in this text; in all likelihood, this material will tend to confuse the student. The last point of constructive criticism is that a list of symbols is not included—this is now an established necessity.

G. B. White, USA

3604. Wundt, W., Hydrology [Gewässerkunde], Berlin, Springer-Verlag, 1953, vi + 320 pp., 185 figs. DM 34.50.

This is a modern European textbook on hydrology from point of view of continental hydrography. Starting with the water circuit on the earth and the problems of water control, book discusses the following aspects: Hydrology and climate—meteorological elements, rainfall, water temperature, snow and ice. Hydrology and geomorphology—geometrical relationships, length, basin areas, development of rivers and lakes, erosion and denudation; underground water, its origin, types; springs; soil moisture. Hydrology and biology—forests, surface cover, transpiration; life in water; chemical ingredients, water quality. Hydrological measurements and statistics—rainfall and discharge observations; discharge curve, duration, depletion curve. Irregular variations of the runoff—floods, their probability; maximal discharge and basin area; low water, climatic variations. Regular fluctuations, annual periods; average runoff, geographical distribution. Storage and water control; natural and artificial reservoirs, annual variations. Integration of the runoff. Concise bibliography (309 titles).

This book, if translated into English, could be an excellent addition to the American texts, which mainly cover the hydraulics of natural runoff.

S. Kolupaila, USA

3605. Mosonyi, E., Scale effect in hydraulic model tests (in French), *Acta Techn. Hung. Budapest* **8,** 1/2, 91–98, 1954.

After general remarks about advantages of scale models, author pays some attention to experiments with flow through porous media. He proposes to introduce the ratio between forces of viscosity and gravity as characteristic dimensionless number, the inertia being unimportant. Grain size is taken as characteristic length.

Reviewer believes that author imposes needless restrictions on seepage models by taking equality of this number in model and prototype as condition for similarity.

In the second part, a superficial exposition is given of possible scale effects in hydraulic models to emphasize the importance of fundamental research in this field.

H. J. Schoemaker, Holland

3606. Franke, P., The similarity requirements in hydraulic models (in German), Mitt. Versuchsanstalt für Wasserbau der Tech. Hochschule München, H.1, 80–100; München, R. Oldenbourg, 1953.

The characteristic numbers, which must be taken into account in order to establish dynamical similarity between model and prototype, are determined by author through well-known dimensional considerations. Inertia, gravity, and friction forces are considered, both separately and in combinations. It is shown that when inertia and friction forces are simultaneously active, the Reynolds similarity law holds only for laminar flow; for turbulent flow, a modified Froude number, containing also the resistance coefficient, must be taken into consideration. If the resistance coefficients in model and prototype are not equal, a deformed scale model must be used, the ratio of the height scale to the length scale being equal to the ratio of the resistance coefficients in prototype and model.

An accurate and complete bibliography on the subject is attached to the article.

P. L. Romita, Italy

3607. Gabrecht, G., Water flow in curved channels (in German), *Wasserwirtschaft* **44,** 2, 3; 29–35, 66–71, Nov., Dec. 1953.

Considering flow in curved channels as potential flow superposed by impulse phenomena, author gives qualitative explanation of minima and maxima in bend losses in pipes for increasing r/d (r is bend radius, d diameter of pipe), of scour, form of water surface, velocity distribution and related phenomena in open channel bends, and of flow vibrating downstream bends. Rules for determining points of impulse reflection and scour are found by experiments and confirmed by examples from nature.

Potential-flow considerations lead author to propose channel bends formed as hyperbolas instead of concentric circular arches. Author limits the divergence angle of the sides of such hyperbolic bends to 11° and the increase of channel width in bend vertex to 30%. He gives detailed instructions in construction of hyperbolic bends. Advantages of the proposed bend form are less

loss of energy, less scour, smaller differences in water level along channel sides, better conditions for navigation. Advantages are confirmed by experiments and traditional rules for canalization.

Paper is abstract of dissertation from Techn. Univ. Karlsruhe, Germany. H. T. Kristensen, Sweden

3608. Flierl, K., Tables and curves for calculations with the energy line for rectangular and trapezoidal channels (in German), Mitt. Versuchsanstalt für Wasserbau der Tech. Hochschule München, H.1, 1–41; München, R. Oldenbourg, 1953.

The well-known equation relating, for a given channel, the height of energy line to water depth and discharge is written in dimensionless form and the properties of the corresponding curve are analyzed and discussed. Numerical tables and curves, representing the simultaneous variation of the dimensionless quantities which appear in the equation, are given, covering all possible trapezoidal cross sections and, as particular cases, the rectangular and triangular cross sections. They are quite helpful for a quick solution of following problems: For given cross section, discharge, and total head, determine the water depth; for given cross section and total head, determine the maximum possible discharge and the corresponding water depth; for given cross section and discharge, determine the minimum necessary total head and the corresponding water depth. The use of the method is very clearly indicated through a number of numerical examples.

P. L. Romita, Italy

3609. Flierl, K., Calculation of the water profile above a trapezoidal sleeper (in German), Mitt. Versuchsanstalt für Wasserbau der Tech. Hochschule München, H.1, 42–62; München, R. Oldenbourg, 1953.

The numerical tables and the curves presented in a previous paper by the same author (see preceding review) are applied to the calculation of the water depth and the total head upstream of and above a trapezoidal sill, placed on the bottom of a trapezoidal or rectangular channel, for given discharge, total head in the undisturbed channel, and height of sill. Head losses between the upstream section and the sill are taken into account. The method is also applied to the determination of the limiting height of the sill, for which critical depth is established above the sill.

P. L. Romita, Italy

3610. Meyer, R., Conditions analogous to those of Thoma in the case of a hydroelectric installation having one surge tank above the turbines and another below them (in French), *Houille blanche* **8**, 5, 640–646, Oct. 1953.

In the first part, the author summarizes a previous paper [*Rev. gén. Elec.* no. 1, 40–46, 1953] on the theory of "perfect regulation." The second part of the present paper deals with the theory of two surge tanks built on each side of the turbines. The fundamental equations are linearized and yield a differential equation of the fourth order. The roots and determinants of the accompanying equations of the fourth degree are analyzed (condition of Hurwitz) and results discussed. The installation is stable if the cross section of each surge tank is greater than the corresponding Thoma cross section. When the two cross sections are just equal to the Thoma cross section, the installation is always slightly unstable. (On the same subject see following review.)

C. Jaeger, England

3611. Escande, L., and Huron, R., Stability of two surge tanks built, respectively, on the head-race and tailrace tunnels (in French), *Houille blanche* **8**, 5, 647–654, Oct. 1953.

Author examines the governing stability of a power station with upstream and downstream surge tanks on each side of the turbines. (This station arrangement may occur with underground power stations.) In the first part of the paper he develops the fundamental equations given in a previous paper by Jaeger [*Schweiz., Bauztg.*, Nov., Dec. 1943]. The analysis of this system of equations leads to an accompanying or characteristic equation of the fourth degree, the roots of which are analyzed (condition of Hurwitz-Routh). Author shows that the Thoma condition for both surge-tank sections is not sufficient for the system to be stable. Numerical calculations show that in some cases the surge-tank areas must be in excess by more than 20% of the value of Thoma. (See also preceding review on same subject.)

C. Jaeger, England

3612. Savic, P., Circulation and distortion of liquid drops falling through a viscous medium, *Nat. Res. Counc. Canad. mech. Engng. Rep.* MT-22, 56 pp., July 1953.

Existing theories of circulation in drops moving through a viscous medium are examined and found to be at variance with observation on water drops moving in castor oil. It is concluded that the suppression of circulation in small drops is due to a surface-active layer, the extent of which is governed by the balance between interfacial tension and the integral of viscous surface shear. The streamline picture and the relation between size of surface layer and drag are found to be in good agreement with experiments, but the critical drop radius for transition from noncirculating to circulating condition is found to be somewhat lower than predicted.

The shape of a distorted drop suspended in a gas stream is calculated and found to be in general qualitative agreement with experiments in a vertical wind tunnel. The difference in wind velocity for breakup between a steady and a suddenly applied gas stream, at least for very small drops, is ascribed to a higher rate of distortion under purely potential motion assumed to exist during a sudden blast. This assumption is shown to agree well with published experimental evidence.

The development from rest of circulation in a drop is calculated for two conditions, viz., when the internal viscosity is high and when it is low compared with the viscosity of the surrounding fluid. It is shown that the time required to attain full circulation in the first case is over four times that in the second case. A numerical example of a kerosene spray in a combustion chamber shows that circulation may be a factor liable to affect the assessment of ignition-delay times.

From author's summary

3613. Pode, L., The deaeration of water by a sound beam, *David W. Taylor Mod. Basin Rep.* 854, 30 pp., May 1953.

The rate of growth of a gas bubble in a sonically irradiated liquid containing dissolved gas is shown theoretically to be proportional to the sound intensity. The calculations are limited to the case of an isolated bubble in a weak sound beam of wave length much greater than the bubble radius and of frequency below the resonant frequency of the bubble. The effects of surface tension, viscosity, and energy dissipation are neglected. The gas compression is assumed adiabatic, although for bubbles below resonant size it is actually more nearly isothermal [Daniels, *J. acoust. Soc. Amer.* **19**, 4, 569–571, July 1947]. Diffusion at the moving boundary surface of the bubble is calculated approximately by a perturbation method. In neglecting surface tension, author finds no threshold effect for bubble growth. He presents growth curves for radii down to 10^{-7} cm, although stating results should not be used much below 10^{-3} cm. Author attributes experimental observation of no definite threshold in fresh tap water, in contrast to usually observed threshold in aged water, to

formation of an organic bubble skin in the aged water rather than to supersaturation of dissolved air in the fresh water.

Author's results differ from those of reviewer [*Acoustics Res. Lab., Harvard Univ. Tech. Mem.* no. 12, Sept. 1949], who included surface tension but omitted resonance effects and motion of boundary in diffusion equation, and from those of M. D. Rosenberg [ibid., *Tech. Mem.* no. 25, Aug. 1952, and no. 26, Aug. 1953], who in a very thorough discussion added the effects of viscosity, heat conduction, sound scattering, and transients. Author compares his results of resonance with reviewer's for zero surface tension, finds them similar in form but differing slightly in numerical constants. Besides removing threshold effect, neglecting surface tension makes calculated rate of growth decrease rather than increase as bubble grows larger.

F. G. Blake, Jr., USA

3614. Bradley, J. N., Morning-glory shaft spillways: Prototype behavior, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 431, 33 pp., Apr. 1954.

3615. Wagner, W. E., Morning-glory shaft spillways: Determination of pressure-controlled profiles. *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 432, 38 pp., Apr. 1954.

3616. Peterka, A. J., Morning-glory shaft spillways: Performance tests on prototype and model, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 433, 42 pp., Apr. 1954.

Incompressible Flow: Laminar; Viscous

(See also Revs. 3603, 3605, 3636, 3648, 3664, 3674, 3677, 3682, 3683, 3721, 3724, 3725)

3617. Oppenheim, A. K., and Baron, T., Fluid dynamics, *Indust. Engng. Chem.* **46,** 5, 922–931, May 1954.

A survey of developments during 1953. Ed.

3618. Free-streamline analyses of transition flow and jet deflection, edited by McNown, J. S., and Yih, C.-S; Elements of free-streamline theory, McNown, J. S.; Transition curves of constant pressure. I. Streamlined struts, Gerber, R., and McNown, J. S. II. Inlets, Appel, D. W., and Laursen, E. M.; Deflection of jets. I. Symmetrically placed V-shaped obstacle, Siao, T. T., and Hubbard, P. G. II. Symmetrically placed U-shaped obstacle, Sarpkaya, T. III. Unsymmetrically placed semi-infinite plate, Ince, S., and Dehaven, C.; Manifold efflux, Toch, A., and Moorman, R. W.; Head losses in miter bends, Ambrose, H. H., *State Univ. of Iowa Studies in Engng. Bull.* **35,** 82 pp., 37 figs., 1953.

Successive conformal transformations involving a hodograph or velocity plane and the application of the Schwarz-Christoffel transformation are employed to determine the flow characteristics of a number of practically important geometric configurations. Experiments were also conducted to determine the applicability of the results to real fluids. Successful predictions are obtained for: the diameter of cavities behind disks; the shape of transition inlets of constant pressure; the contraction coefficient for partially confined jets; the deflection angles of jets impinging on U-shaped boundaries; the jet angle and contraction coefficients of jets issuing from lateral orifices; and the head loss (through determination of contraction coefficients) in miter bends.

With the assumption that area ratios are comparable, the two-dimensional results were employed with surprising success to predict the behavior of three-dimensional axisymmetric flows.

The series was prepared by graduate students as part of a pedagogical experiment in education through original investigation. Reviewer regards results rewarding. J. P. Craven, USA

3619. Schaaf, S. A., and Sherman, F. S., Skin friction in slip flow, *J. aero. Sci.* **21,** 2, 85–90, Feb. 1954.

Skin-friction data in the slip flow regime are presented, covering the range: $0.008 < M/Re^{1/2} < 0.38$; $34 < Re < 2020$ for $2.5 < M < 3.8$; $3 < Re < 500$ for $M \sim 0.2$ and 0.6. It is inferred that, in the neighborhood of $Re = 1000$, the dominant effect is the interaction between boundary layer and external flow, which increases the skin friction, but that in the neighborhood of $Re = 50$ the dominant effect is that of slip, which decreases the skin friction. These inferences, particularly the former, are in accord with the results of theoretical studies such as those by S. A. Maslen [AMR **6,** Rev. 1342] and Y. H. Kuo [*J. Math. Phys.* **32,** no. 2–3, July–Oct., 1953]. However, in analyzing the data, the authors of the subject report do not appear to distinguish between compressibility (variable fluid property) effects and those due to boundary-layer external-flow interactions and slip.

H. Mirels, USA

3620. Aronofsky, J. S., Effect of gas slip on unsteady flow of gas through porous media, *J. appl. Phys.* **25,** 1, 48–53, Jan. 1954.

A numerical method is presented for describing either the one-dimensional or radial transient flow of gases through a porous medium in which initial and final pressures and/or rates are specified. The effect of a pressure-sensitive gas permeability resulting from gas slip is estimated by assuming the permeability to vary linearly with the reciprocal pressure. The computations are carried out on punch-card machines. The effect of gas-slip permeability is found to be small under conditions usually associated with gas or petroleum reservoirs, and is considered to be of most importance for experiments in the laboratory. A possible transient method for determining porosity and gas-slip corrected permeability is suggested. A. H. Sacks, USA

3621. Isay, W. H., On the potential flow through airfoil cascades (in German), *ZAMM* **33,** 12, 397–409, Dec. 1953.

The problem of determination of the potential flow through a cascade of airfoils is formulated as an integral equation for the vorticity distribution. Airfoils with zero thickness as well as with finite thickness are considered, where, for the latter, the representative singularity distribution (vortexes) is taken along the airfoil contour.

With the method of W. Schmeidler, the integral equation of the first kind for the vorticity distribution is transformed to a matrix equation of infinite order. Under certain conditions, the matrix equation can be solved by iteration, which suggests itself after splitting the kernel in singular and regular part. Generally, the matrix equation can be solved by using finite approximations for the infinite matrixes.

Furthermore, author considers the configuration of two interfering blade rows, where the blades may have arbitrary camber and thickness, and develops a similar analysis as for the single-blade row. H. G. Loos, Holland

3622. Fomichev, M. S., Structure of a flow behind a flat plate in a viscous fluid (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 8, 1157–1165, Aug. 1953.

The fluid is water, 54 cm deep, flowing in a turbulent manner through an open glass channel 60 cm wide at a Reynolds number of 116,000. Spherical tracers, 1–1.5 mm in diam, made of a mixture of chlorobenzene and vaseline so as to match the density

of water, are introduced far upstream, illuminated by a narrow light beam through the floor and photographed with 0.11-sec exposures. Single exposures of the whole flow field of the undisturbed flow and of flows with flat plates 2.25, 4.5, and 9.5 cm high (spanning the channel perpendicularly to the flow) are analyzed to give local instantaneous horizontal and vertical velocity components, $\bar{u}$ and $\bar{v}$, in Fig. 4, and their instantaneous product $\bar{u}\bar{v}$ in Fig. 5. For a nondimensionalized measure of local vorticity the author takes the ratio of $(\bar{u}\bar{v})^{1/2}$ to the spatial mean of the same quantity in the undisturbed flow (Fig. 6). The only general statement is that the distance L needed for the local vorticity to decay to the free-stream value is approximately 35 to 40 heights of the plate.

There are no time statistics, no instantaneous special correlations. The scatter evident from the graphs indicates that the technique would have to be considerably improved to give reliable information even about the large-scale turbulence.

M. V. Morkovin, USA

3623. Poritsky, H., The collapse or growth of a spherical bubble or cavity in a viscous fluid, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 813–821, 1952.

In the equations of motion in incompressible flow, for the growth or collapse of a spherical cavity it appears that the terms containing the viscosity disappear. But the proper evaluation of the pressure inside the cavity shows up in prescribing boundary condition. Through this boundary condition, the effect of viscosity on the growth or collapse of a spherical bubble is investigated. An example is worked out, giving the details of solving the differential equation.

The effect of surface tension is also considered. It is shown that without surface tension the complete collapse of bubble is never reached. Also the effect of surface tension is to slow down the rate of expansion of the bubble at first, but not in the later stages of expansion.

G. V. R. Rao, USA

Compressible Flow, Gas Dynamics

(See also Revs. 3603, 3617, 3651, 3652, 3655, 3657, 3671, 3700, 3723)

3624. Czarnecki, K. R., Robinson, R. B., and Hilton, J. H., Jr., Investigation of distributed surface roughness on a body of revolution at a Mach number of 1.61, *NACA TN* 3230, 35 pp. June 1954.

The results indicate that the effects of surface roughness at a Mach number of 1.61 are generally similar to those found at subsonic speeds. Both the allowable roughness height for a turbulent boundary layer and the variation with Reynolds number of the increment in skin-friction drag due to roughness are in good agreement with Nikuradse's low-speed data.

From authors' summary by A. Petroff, USA

3625. Hilton, J. H., Jr., and Czarnecki, K. R., An exploratory investigation of skin friction and transition on three bodies of revolution at a Mach number of 1.61, *NACA TN* 3193, 15 pp., June 1954.

The results indicated marked differences in the transition Reynolds numbers for the three bodies of revolution and, in general, the effects of pressure gradient at a Mach number of 1.61 were qualitatively similar to those obtained at subsonic speeds. The results also indicate that, for a turbulent boundary layer, pressure gradients have little or no effect on the average skin-friction coefficients for the types of bodies investigated.

From authors' summary by A. Petroff, USA

3626. Parker, H. M., Minimum-drag ducted and pointed bodies of revolution based on linearized supersonic theory, *NACA TN* 3189, 30 pp., May 1954.

The formula for the drag of a body of revolution in steady, linearized, supersonic flow, in terms of the source distribution along the axis, is written down without slender-body approximations; it involves a triple integral over the body length coordinate. By means of a simple trick the author is able to reduce this to a double integral involving an arc cosh. This result reduces immediately to the familiar slender-body formula of von Kármán and Ward, where the $\cosh^{-1}$ becomes a logarithm and the source distribution is related to the cross-sectional area distribution, in the appropriate case. Lighthill has shown that, for smooth bodies, the slender-body formula is as accurate as the linearized theory. The new formula, however, is not restricted to smooth bodies.

The author proceeds to use his new drag formula to determine minimum-drag body shapes that may not involve smooth bodies. The problem treated is that of the optimum transition section connecting two semi-infinite cylinders. The auxiliary condition for this case can be expressed in terms of the source distribution. The optimum distribution function is part of an ellipse. The geometry of the optimum shapes is exhibited and discussed. The special case of the projectile tip (radius of one of the cylinders is zero) yields shapes differing from that found by von Kármán, and having lower drags. These tips have nonzero slopes at the rear, where they join the cylinder.

W. R. Sears, USA

3627. Pai, S. I., On the flow behind an axially symmetrical attached curved shock, *J. Franklin Inst.* **257**, 5, 383–398, May 1954.

The flow behind a curved shock attached to a nearly conical body of revolution is investigated by considering the perturbation of the stream function in the Taylor-Maccoll solution for a cone. Solutions of the linear differential equations are found for the weak and strong shock case. In the transonic case, a special first-order differential equation for the perturbed stream function valid in the neighborhood of Mach number equal to 1 is found. This equation is used to join the solutions for the supersonic and the subsonic flows.

From author's summary by W. Wuest, Germany

3628. Zwikker, C., Physics of the sound barrier (in Dutch), *Ingenieur* **66**, 18, A217–A219, Apr. 1954.

3629. Oguchi, H., On the subsonic flow behind the bow wave of a finite wedge, *J. phys. Soc. Japan* **9**, 2, 249–255, Mar./Apr. 1954.

Author uses Lighthill's linearized theory of rotational flow, involving a modified complex potential, to find the flow past a finite wedge in a uniform supersonic stream when an attached curved shock produces subsonic flow between the leading edge and shoulder. Both plane and curved wedge surfaces are considered.

Maurice Holt, England

3630. Spreiter, J. R., and Alksne, A., Theoretical prediction of pressure distributions on nonlifting airfoils at high subsonic speeds, *NACA TN* 3096, 84 pp., Mar. 1954.

The flow over a circular-arc airfoil is computed, using the integral method of Oswatitsch with, however, a modified iteration process which eliminates some of the shortcomings of the iteration process used by Oswatitsch.

Aside from the usual premise of small perturbations, the following are some of the assumptions made in the method:

(1) The inverse of the pressure varies parabolically with the lateral distance from the profile. (This assumption is never approached under any practical limiting process.)

(2) The shock wave which arises is a normal shock which is perpendicular to the free-stream direction. (As implied in the paper, the shock-wave configuration does not assume this form in the limit that the profile thickness approaches zero.)

Despite these severe assumptions (the effects of which are difficult to appraise), the final results appear reasonable.

In expressing the drag coefficient in a reduced form, authors suggest another form which differs from the usual one derived from the transonic similarity law by higher-order terms, but which agrees better with experiment in the case of semi-infinite bodies. (In the case of closed bodies, however, this improvement in the agreement with experiment would probably be considerably less.) H. Yoshihara, USA

3631. Manwell, A. R., The variation of compressible flows, *Quart. J. Mech. appl. Math.* **7**, part 1, 40–50, Mar. 1954.

It has been conjectured that under slight change of original boundary, the steady transonic flow of the perfect compressible fluid may be unstable. Present paper concerns use of variational method to show that perturbed potential and stream function in both physical and hodograph plane have distinct solutions and are not necessarily critical as usually believed, even if the Jacobian of the transformation is zero. The theory is applied to transonic circulatory flow outside a circular cylinder. It is found that for most changes of the boundary there exist corresponding small changes of the flow. However, near many speeds of the stream at the boundary there are critical perturbations which give proportionately large changes of the flow through a resonance process. It is believed that the critical speeds themselves are characterized by the nonuniqueness of the Dirichlet problem for the perturbation and, consequently, for the original physical flow.

C.-C. Chang, USA

3632. Jones, C. W., On gas flow in one dimension following a normal shock of variable strength, *Proc. roy. Soc. Lond.* (*A*) **221**, 1145, 257–267, Jan. 1954.

The problem of the nonuniform propagation of a normal shock wave and of the nonhomentropic one-dimensional flow behind it is considered with the use of the equations of motion in Lagrangian form, entropy and time as independent variables. A particular family of exact solutions is developed and it is indicated how the actual solution, essentially dependent on a single first-order differential equation of a standard type, may in principle be found by quadratures. A particular member of the family corresponding to a shock advancing with a velocity which varies as the $-n/(n+2)$ power of the time into a region of gas initially at rest with a uniform pressure and a density varying as the nth power of the distance downstream ($n > -2$) is studied for strong shocks, and it is shown that similar results apply for shocks of arbitrary strength. The case $n = 1$ is studied in detail. The extension to spherically symmetric shocks is shown to be straightforward. P. Chiarulli, USA

3633. Nikol'skiĭ, A. A., Problems of gas flow at sonic speeds (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **94**, 3, 401–404, Jan. 1954. (English translation by M. D. Friedman is on file with Scientific Translation Division, Library of Congress.)

Author solves the problem of an isentropic jet issuing from a slit at the speed of sound into a medium at arbitrary pressure. Solution of the full isentropic equations is carried out in the hodograph plane by means of a series; analytic formulas are obtained, but no examples are worked out. Extensions to flows past wedges and in rectilinearly expanding channels are suggested. L. Trilling, USA

3634. Ness, N., and Kaplita, T. T., Tabulated values of linearized conical flow solutions for solution of supersonic conical flows without axial symmetry, *Poly. Inst. Brooklyn, PIBAL Rep.* no. 220, 260 pp., Jan. 1954.

3635. Gilbarg, D., and Shiffman, M., On bodies achieving extreme values of the critical Mach number, I, *J. rational Mech. Analysis* **3**, 2, 209–230, 1954.

In connection with the design of airfoil sections achieving maximum critical Mach number, authors solve the following problems exactly for inviscid compressible flow past symmetrical plane sections: (1) Among all profiles with given thickness ratio, to determine the shape achieving maximum critical Mach number. (2) Among all profiles having given width and given maximum curvature, to determine the shape achieving the minimum critical Mach number. The result for problem (1) also solves the maximum problem for an airfoil of given length and enclosing given area. A theorem is conjectured which leads to some similar results for axially symmetrical flows. Proofs of results are based on comparison method. G. N. Ward, England

3636. Kelber, C., Transient flows in axisymmetric nozzles operating at high pressures, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 567–578, 1953.

Some preliminary observations are reported on short-duration high-pressure gas flow from a single and a twin nozzle. Using inflammable gas mixture with ignition caused by passing through shock fronts, the shock-bottle and Mach-disk configuration and formation of vortex ring are recorded with high-speed motion-camera technique. Color photographs give some idea about temperature distribution. G. Huss, Sweden

3637. Liger, M., New approximative equation for the study of subsonic and transonic flows (in French), *ONERA Publ.* no. 64, 48 pp., 1953.

Paper transforms the dependent and both independent variables in Tricomi's equation such that the resulting equation can be interpreted as an approximation to the hodograph equation. Solutions of Tricomi's equation thus yield approximate hodograph solutions but with changed boundary. Method is applied to sonic free jet (comparison with solution of exact equation), to subsonic and transonic flows over a number of profiles, and to the wedge at Mach number 1. For a suitable wedge angle (determined by the approximation of the hodograph), solution is strikingly simple. G. Guderley, USA

3638. Blanch, Gertrude, and Fettis, H. E., Subsonic oscillatory aerodynamic coefficients computed by the method of Reissner and Haskind, *J. aero. Sci.* **20**, 12, 851–853, Dec. 1953.

Numerical values for aerodynamic coefficients for an oscillating airfoil in subsonic flow, given by Timman and van de Vooren, differed appreciably from Dietze approximate values. The former were claimed to be exact, based on Mathieu functions expressions for the acceleration potential. Present authors computed numerical values by Reissner and Sherman's exact expression for the velocity potential in Mathieu functions. Results are in excellent agreement with the values of Dietze, of Turner and Rabinowitz, and of Fettis, which are calculated by an approximate method for solution of Possio's integral equation and which satisfy Fettis' reciprocity relations.

Reviewer's remark: The discrepancy is now shown to be due to a computational error in the Mathieu functions, used in the reviewer's values. Reviewer's expressions do satisfy analytically the reciprocity relations. Corrected values are in good agreement with those of Dietze and satisfy reciprocity relations.

R. Timman, Holland

3639. Thomas, T. Y., Sonic point on supersonic airfoils, *Proc. nat. Acad. Sci. Wash.* **40,** 2, 76–83, Feb. 1954.

In the case of supersonic flow with detached shock, formulas are derived for computing approximately the surface angle at point on body where sonic line meets airfoil. J. S. Isenberg, USA

3640. Kuessner, H. G., A general method for solving problems of the unsteady lifting surface theory in the subsonic range, *J. aero. Sci.* **21,** 1, 17–26, 36, Jan. 1954.

An oscillating lifting surface of any shape with any downwash distribution may be given. The Kutta condition of finite velocity at the trailing edge can be satisfied in a general way only if one introduces appropriate orthogonal coordinates. The lifting surface must be a member of the family of orthogonal surfaces. Corresponding wave functions have to be used by which the wave equation can be separated. By means of these functions a characteristic function G may be constructed, the normal derivative of which at the lifting surface has the properties of a Dirac δ-function. The kernels of the integrals, which represent the exact velocity potential and the pressure, are composed of this function G and its derivatives. Examples are given for the elliptic and circular plate and for the infinite long ribbon, for which the wave functions are known. The solution of the two-dimensional case is also given.

From author's summary by G. V. R. Rao, USA

3641. Lees, L., Hypersonic viscous flow over an inclined wedge, *J. aero. Sci.* **20,** 11, 794–796, Nov. 1953.

3642. Pai, S-I., On strong interaction for the hypersonic boundary layer on an inclined wedge, *J. aero. Sci.* **20,** 11, p. 796, Nov. 1953.

Author's closure on the discussions contribution by Dr. Lester Lees (preceding review). Ed.

3643. Guderley, G., and Yoshihara, H., Two-dimensional unsymmetric flow patterns at Mach number 1, *J. aero. Sci.* **20,** 11, 757–768, Nov. 1953.

See AMR **5,** Rev. 3149.

3644. Ferrari, C., Determination of the external contour of a body of revolution with a central duct so as to give minimum drag in supersonic flow, with various perimetral conditions imposed upon the missile geometry, *Cornell Aero. Lab. Rep.* AF-814-A-2, 90 pp., Nov. 1953.

Several numerical examples have been worked out in detail, by application of a theoretical procedure developed in part I of this study [AMR **7,** Rev. 1544], in order to determine, consistent with the accuracy inherent in the use of linear theory, what the optimal contour of an annular duct must be if it is to produce minimum external wave drag in supersonic flow, under the stipulations that either (1) the area enclosed between the sought contour and its inner conelike wall is to have a set constant value, measured in any meridional plane through the duct's axis, or (2) the volume, enclosed between the surface of revolution swept out when the sought meridional contour is rotated about its axis and the frustum-of-a-cone inner surface, is to be a constant given value.

From author's summary by N. Tetervin

3645. Pearson, J. D., The transient motion of sound waves in tubes, *Quart. J. Mech. appl. Math.* **6,** part 3, 313–335, Sept. 1953.

This paper falls into two parts: (1) The study of transient motion of sound waves in an infinite tube of constant cross section; (2) investigation of the effect of slight distortion of the cross section. In the first part, a formula is obtained for the velocity potential by use of Heaviside's operators, and an asymptotic expression for this is then found by the method of steepest descent. In the second part of the paper, a series solution is obtained for the velocity potential in a tube of slightly variable cross section. The particular case of a tube of near rectangular cross section is investigated, and for such a tube a longitudinal harmonic distortion is considered in detail.

From author's summary by M. A. Heaslet, USA

3646. Cunsolo, D., On a practical method of rapid graphical solution of problems in two-dimensional supersonic flow (in Italian), *Aerotecnica* **33,** 2, 166–169, Apr. 1953.

3647. Hida, K., On the subsonic flow of a compressible fluid past a prolate spheroid, *J. phys. Soc. Japan* **8,** 2, 257–264, Mar.-Apr. 1953.

Janzen-Rayleigh method is used to obtain velocity distributions and critical Mach numbers, correct to order M^2, for prolate spheroids of fineness ratios 0.9 and 0.1

A. E. Bryson, Jr., USA

Turbulence, Boundary Layer, etc.

(See also Revs. 3622, 3625, 3666, 3721, 3747, 3774)

3648. Mitchner, M., Propagation of turbulence from an instantaneous point disturbance, *J. aero. Sci.* **21,** 5, 350–351, May 1954.

A brief account of flow distortion resulting from an artificial instantaneous point disturbance for two different types of shear flow is given. One case was a disturbance at the free surface of water in laminar flow in an inclined channel, and the second case was a disturbance produced in the critical laminar boundary layer of air flowing over a flat plate. The results indicate that Emmons' recent "point source" theories explaining laminar to turbulent boundary-layer transitions may have some merit.

R. J. Mindak, USA

3649. Batchelor, G. K., and Proudman, I., The effect of rapid distortion of a fluid in turbulent motion, *Quart. J. Mech. appl. Math.* **7,** part 1, 83–103, Mar. 1954.

For turbulent flow subjected to sudden change of shape either by boundary or by large-scale turbulent velocity, authors compute effect on homogeneous turbulence. Problem is linearized by neglecting viscous decay and assuming that distortion is uniform. It is shown that most wind-tunnel contractions do not satisfy these conditions, hence no attempt is made to compare with experiments. Energy spectrum tensor is used to derive algebraic expression for effect on each component of intensity of turbulence. Authors show that initially isotropic turbulence is rendered anisotropic. Two particular cases are examined in detail, namely, symmetrical contraction and effect of arbitrary distortion on total turbulent energy. Much of the material in paper has been covered by Ribner and Tucker [AMR **6,** Rev. 1345] and Batchelor [AMR **6,** Rev. 2855]; however, reviewer finds results more generalized than previously given. Reviewer recommends paper because it is clearly and concisely written.

W. D. Baines, Canada

3650. **Townsend, A. A., The uniform distortion of homogeneous turbulence,** *Quart. J. Mech. appl. Math.* **7,** part 1, 104–127, Mar. 1954.

Studies were made in a wind tunnel having constant cross-section area but with expanding sides and contracting roof and base. Flow with isotropic turbulence was generated upstream and author made measurements on resulting turbulence along center line of tunnel. Results show that rate of decay of turbulent energy is less than for an undistorted stream. Also, turbulence becomes anisotropic, but dissipating eddies return to isotropy rapidly when distortion ceases. Comparison to theory of Batchelor and Proudman (see preceding review) for instantaneous distortion is made, but conditions for theory do not apply. Author concludes that, for small strains, the structure of the energy-containing eddies is similar to that described by theory. Discussion of significance of results is included and this is carried on to equilibrium structure in shear flows. Eddy-viscosity hypothesis is considered, but it is concluded that its applicability to shear flows is accidental. W. D. Baines, Canada

3651. **Illingworth, C. R., The effect of heat transfer on the separation of a compressible laminar boundary layer,** *Quart. J. Mech. appl. Math.* **7,** part 1, 8–34, Mar. 1954.

Under the assumptions that Prandtl number is unity and viscosity coefficient is proportional to absolute temperature, an approximate method is developed for treating the compressible laminar boundary layer for nonuniform stream velocity and wall temperature. The method is similar to that used by Lighthill [AMR **4,** Rev. 2612]. Some examples of flow problems are worked and compare favorably with more exact solutions. These show, for instance, that for low-speed flow over a heated surface both skin friction and heat transfer are increased for accelerated flow and decreased for retarded flow. In a gentle adverse downstream velocity gradient, the results show that the effects of increasing the temperature of the surface hasten flow separation. The method should be quite useful even though it is best suited to the construction of solutions from which the associated main velocity and wall-temperature distributions are derived.

A. M. Keuthe, USA

3652. **Smith, J. W., Effect of diffusion fields on the laminar boundary layer,** *J. aero. Sci.* **21,** 3, 154–162, 178, Mar. 1954.

The diffusion of a foreign gas into a laminar boundary layer and on a flat plate in steady compressible flow is studied in connection with the reduction of aerodynamic heating at hypersonic speeds. The momentum, energy, and diffusion equations are transformed into a set of integral equations which are solved by a method of successive approximations.

Sample calculations indicate that when helium is allowed to diffuse into an air boundary layer at $M = 8$, the direction of heat flow is reversed, whereas at $M = 12$ the influx of heat is practically eliminated. G. M. Lilley, England

3653. **Schubauer, G. B., Turbulent processes as observed in boundary layer and pipe,** *J. appl. Phys.* **25,** 2, 188–196, Feb. 1954.

Author compares certain statistical properties of turbulence observed in a boundary layer and in fully developed pipe flow. Differences and likenesses are shown. For instance, when the turbulence intensity is plotted against the distance from the wall in terms of the boundary-layer thickness, a disagreement is found between the curve for pipe flow and that for boundary-layer flow. If intermittency is taken into account, however, this disagreement disappears for sufficiently high Reynolds numbers. This revealing comparison is an example showing the physical insight behind the lucid interpretation which one finds throughout the paper. Certain common properties for the two types of flow are found which appear to be indicative of processes governing the finer structure and controlling the origin, form, and life cycle of turbulent motions, and an excellent attempt is made to point out some of these processes. Attention is called to the region of high turbulent activity near the wall.

Reviewer believes that paper contributes significantly to the understanding of turbulence structure in shear flow.

C.-S. Yih, USA

3654. **Clauser, F. H., Turbulent boundary layers in adverse pressure gradients,** *J. aero. Sci.* **21,** 2, 91–108, Feb. 1954.

Paper presents the results of a promising experimental approach to the behavior of turbulent boundary layers under the influence of adverse pressure gradients. The experiments were carried out in a specially constructed low-turbulence wind tunnel with sufficient length to permit growth of a thick boundary layer, and with various devices for creating desired longitudinal pressure gradients.

Due to the great influence of the previous history of a boundary layer on its characteristics, the present approach has been simplified by establishing profiles with constant histories. This was done by adjusting the pressure gradient so that velocity profiles at all stations along the wall were of similar shape when plotted in a set of universal, dimensionless coordinates.

Results were presented in such a way as to separate the effects of Reynolds number, pressure gradient, and roughness on skin friction. In particular, it was shown that adverse pressure gradients have a stronger influence on the skin-friction coefficient than generally assumed, and that moderately high adverse gradients exhibit downstream instability.

Comparison of the experimental results with some methods now in use for predicting pressure gradient effects on turbulent boundary layers showed poor agreement. This would indicate that much further systematic experimental research of this nature is needed in order to approach the objectives of providing a reliable method of predicting the behavior of turbulent boundary layers under the influence of pressure gradients.

F. L. Wattendorf, USA

3655. **Libby, P. A., and Morduchow, M., Method for calculation of compressible laminar boundary layer with axial pressure gradient and heat transfer,** *NACA TN* 3157, 44 pp., Jan. 1954.

Approximate solution of two-dimensional boundary layers with prescribed free-stream Mach number and velocity distribution is developed by applying the integral method to both the momentum and energy equations. A sixth-degree velocity profile and a seventh-degree stagnation-enthalpy profile are used, involving a single boundary-layer thickness and one of the coefficients in the thermal profile as the parameters to be determined. Numerical examples show satisfactory accuracy as compared to the well-known Chapman and Rubesin results. S. F. Shen, USA

3656. **Newman, B. G., Some contributions to the study of the turbulent boundary-layer near separation,** *Aero. Res. consult. Comm. aero. Res. Lab. Melbourne, Austral., Rep.* ACA-53, 40 pp., Mar. 1951, published 1953.

Experimental and theoretical studies of the turbulent boundary layer near separation in subsonic incompressible flow are made. Author concludes that the form parameter is insufficient to describe the state of the turbulent boundary layer and that the von Kármán momentum equation is invalid near separation by the omission of two terms. A generalized momentum equation containing a second order of approximation is then derived which is

not confirmed by the experimental results in detail, although these additional terms near separation are of magnitudes several times the skin-friction coefficient. A relation for the skin friction at the wall, derivable from the mean flow, is also found by dimensional analysis of the flow in the laminar sublayer.

It is noted that Clauser ["Turbulent boundary layers in adverse pressure gradients," Johns Hopkins Univ. Rep., June 1953] has pointed out that the disagreement of experimental results with the von Kármán momentum equation is probably due to the fact that the flows investigated were not two-dimensional; moreover, they could not be accounted for by the additional terms in the momentum equation. H. G. Lew, USA

3657. Monaghan, R. J., An approximate solution of the compressible laminar boundary layer on a flat plate, *Aero. Res. Counc. Lond. Rep. Mem.* 2760, 24 pp., Nov. 1949, published 1953.

By assuming that enthalpy and velocity are dependent only on local conditions and by accepting relations obtained by Crocco, an approximate enthalpy-velocity relation is obtained for the laminar boundary layer on a flat plate with $\partial p/\partial x = 0$ and $\partial i/\partial x = 0$. This relation gives a close approximation to Crocco's numerical results for $\sigma = 0.725$ and 1.25 up to $u/u_1 = 0.8$. By taking a viscosity temperature relation of the form $\mu/\mu_1 = CT/T_1$ as proposed by Chapman and Rubesin, where C is a constant, the variation of shearing stress across the layer when $\partial p/\partial x = 0$ and $\partial i/\partial x = 0$ is shown to be independent of C and an approximation suggested by Young is adopted. The local skin-friction coefficient C_f can serve to determine C. Approximate formulas for C_f are already available for $\sigma = 0.725$ and a new generalization for other values of σ is suggested. Approximate formulas for displacement thickness and velocity distribution are then derived, which are in very close agreement, at least up to $M_1 = 5.0$, with some representative cases obtained by numerical integration of more exact formulas.

From author's summary by F. H. Clauser, USA

3658. Bergmann, H. G., The boundary layer problem for certain nonlinear ordinary differential equations, *Compositio Math.* **11**, 119–169, 1953.

Author studies the boundary-layer effect in connection with the boundary-value problem

$$p_{xx} = q^2/2, \quad kq_{xx} + pq = 0, \quad k > 0, \quad -1 \leq x \leq 1,$$
$$p(-1) = p_1, \quad p(1) = p_2, \quad q_x(-1) = q_x(1) = 0 \qquad [1]$$

as the parameter $k \to 0$. In case $p_1 > 0$ the transformation $t = (x+1)(p_1/k)^{1/2}$, $P = p/p_1$, $Q = k^{1/2}q/p_1$ converts [1] to a boundary-value problem on the interval $0 \leq t \leq a = 2(p_1/k)^{1/2}$. As $k \to 0$ there arises the asymptotic problem [2] $P_{tt} = Q^2/2$, $Q_{tt} + PQ = 0, 0 \leq t < \infty$, $P(0) = 1$, $Q_t(0) = 0$ with $Q(t)$ required to be continuous and its derivatives required to satisfy suitable integrability conditions on the interval $0 \leq t < \infty$. This asymptotic problem is the same as that treated by Friedrichs and Stoker [*Amer. J. Math.* **63**, 839–888, 1941] and results obtained by them are used in part in the present paper. The methods of the present paper parallel those of Friedrichs and Stoker, but in addition the author supplies a proof of the convergence of certain power series for $P(t)$ and $Q(t)$ which were introduced by Friedrichs and Stoker in connection with the asymptotic problem [2]. If $q^k(x)$ and $p^k(x)$ denote the solution of [1], then the main results stated by the author may be summarized as follows: If both $p_1 < 0$ and $p_2 < 0$, then

$$q^k(x) = 0, \quad p^k(x) = \tfrac{1}{2}[(p_2 - p_1)x + (p_2 + p_1)]$$

for all $k > 0$; if either $p_1 > 0$ or $p_2 > 0$ or both, then $k^{1/2}q^k(x) \to 0$, $p^k(x) \to p^0(x)$ uniformly in every interval $-1 < x_- \leq x_+ < 1$ as $k \to 0$, where $p^0(x) = \frac{1}{2}[(\gamma_2 p_2 - \gamma_1 p_1)x + (\gamma_2 p_2 + \gamma_1 p_1)]$ and $\gamma_i = 1$ if $p_i < 0$ and $\gamma_i = -0.47271$ if $p_i > 0$. That is, there is a boundary-layer effect if the boundary value is positive and otherwise not. The inequality (3.19) of the present paper is clearly misprinted, but even after this is corrected to what was evidently intended, the inequality does not follow in the manner indicated by the author. Indeed, the first inequality of (3.20), which is deduced from (3.19), is not true in general for $k < 1/2$, as the counterexample $q(x) = \sin n\pi x$ shows if n is sufficiently large. The reviewer did not determine what effect, if any, this error has on the validity of the results stated above.

Courtesy of Mathematical Reviews C. E. Langenhop, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 3464, 3467, 3635, 3639, 3644, 3672, 3700, 3736, 3737, 3778)

3659. Donegan, J. J., Robinson, S. W., Jr., and Gates, O. B., Jr., Determination of lateral-stability derivatives and transfer-function coefficients from frequency-response data for lateral motions, *NACA TN* 3083, 61 pp., May 1954.

A technique for determination of lateral stability derivatives of aircraft from flight test data in form of frequency-response characteristics is described. These data are substituted into the three lateral equations of motion, and subsequent separation of real and imaginary derivatives yields six equations which are then fitted to data by least squares. Numerical examples are given. L. Becker, USA

3660. Frayn, E. M., and Parnell, M. V., The theoretical effect of flight path angle on the lateral stability and response of an aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* 2529, 28 pp., Nov. 1945, published 1954.

Lateral response of a dive-bomber airplane to various disturbances has been calculated for steady angles of dive of 0°, 30°, 60°, 90°, using standard lateral stability equations solved by the Laplace transformation. It is shown that the effect of increased dive angle is to increase the spiral stability, modify the Dutch-roll mode slightly, and make the response to a rolling moment less oscillatory.

Effect of dive angle on spiral stability is expected because of stabilizing effect of component of gravity along flight path, regardless of lift coefficient. Effects of dive angle on response, however, result partly from assumed variations of stability derivatives l_r and n_p with lift coefficient in a steady dive. These effects are not, therefore, directly due to flight-path inclination, and would be expected to be reduced if constant lift coefficient were assumed. W. H. Phillips, USA

3661. Zbrozek, J., Investigation of lateral and directional behaviour of single rotor helicopter (Hoverfly Mk. I), *Aero. Res. Counc. Lond. Rep. Mem.* 2509, 20 pp., June 1948, published 1953.

Simplified analysis is given of rolling and yawing motion of helicopter with a single main rotor and a tail rotor. One type of free motion is a heavily damped rolling motion, while a second type is a spiral motion stable for the range of speeds investigated. Third type is a lateral oscillation stable at most speeds, except at and near hovering. Analysis is based on theoretical derivation of stability derivatives by use of various simplifying assumptions. Numerical results based on the Sikorsky R4-B helicopter are presented. In addition to the free lateral motion, the response of the helicopter (giving angle of bank as a function of time) to a sudden increase of tail-rotor pitch is calculated.

Among other conclusions resulting from the calculations, it is found that an increase of main-rotor pitch destabilizes the lateral oscillations, while an increase of the moment of inertia of the blades increases the damping of the lateral oscillation. Comparison of the theory with experiment is discussed in some detail.

M. Morduchow, USA

3662. **Kelly, J. A., and McCullough, G. B., Aerodynamic loads on a leading-edge flap and a leading-edge slat on the NACA 64A010 airfoil section,** *NACA TN* 3220, 33 pp., June 1954.

Tables of chordwise distribution of pressure measured concurrently with force and moment data of *NACA TN* 3007 [AMR 7, Rev. 883] are presented together with graphs of derived loads data for leading-edge flap and slat ($R = 6 \times 10^6$, $M = 0.17$).

J. S. Isenberg, USA

3663. **Tolhurst, W. H., Jr., Downwash characteristics and vortex-sheet shape behind a 63° swept-back wing-fuselage combination at a Reynolds number of 6.1 × 10⁶,** *NACA TN* 3175, 45 pp., May 1954.

Experimental data on the vortex-sheet shape in incompressible flow are presented. At positive angles of attack, vortex-sheet shape initially bowed upward but flattened out downstream before rolling-up process had progressed to appreciable degree. Plots of downwash angles are presented for several angles of attack. Comparison with theory showed that acceptable approximation to downwash distribution within the distance surveyed is obtained by assuming vortex sheet flat and spanwise vorticity distribution that of wing.

K. C. Harder, USA

3664. **Fujikawa, H., The lift on the symmetrical Joukowski aerofoil in a stream bounded by a plane wall,** *J. phys. Soc. Japan* 9, 2, 233–239, Mar./Apr. 1954.

The lift on the symmetrical Joukowsky airfoil of small thickness in the presence of a plane rigid wall is obtained in the form of a power series. It is found that, as the distance of the airfoil from the wall is decreased, the lift first decreases and then increases to a value greater than that for a Joukowsky airfoil in an infinite stream. It is also found that, for a given distance from the wall, the ratio of the actual lift to the corresponding lift in an infinite stream decreases as the airfoil thickness increases. No comparison with experiment is given.

L. C. Woods, Australia

3665. **Fujikawa, H., Note on the lift acting on a circular-arc aerofoil in a stream bounded by a plane wall,** *J. phys. Soc. Japan* 9, 2, 240–243, Mar./Apr. 1954.

This is a continuation of previous paper (see preceding review), extending the method to the case of a circular-arc airfoil. The paper shows how the ground effect on airfoil lift is modified by camber, the main conclusions being that, as the distance from the wall is reduced, the lift first decreases and then increases to a value greater than that in an infinite stream, and that the rate of this lift increase becomes smaller as the airfoil camber increases.

L. C. Woods, Australia

3666. **Black, J., Pressure distribution and boundary layer investigations on 44 degree swept-back tapered wing, Parts I and II,** *Aero Res. Counc. Lond. curr. Pap.* no. 137, 51 pp., 1953.

An experimental investigation of the aerodynamic characteristics of a tapered wing with a leading edge swept back 44° has been carried out in a wind tunnel at a Reynolds number of 9.5 × 10⁶, based on a mean chord of 10 in.

Chordwise pressure distributions at a number of spanwise locations were measured over a range of incidence. Considerable attention was given to investigating the boundary layer, quantitative measurements being made with a novel form of yaw-meter head, and the flow being studied visually using wool tufts. In addition, a technique for revealing the direction of flow and formation of vortexes in the layer was developed; this consists of spraying the wing with a suspension of lampblack in paraffin with the wind off and then turning the wind on rapidly.

One of the most important results established was the relation of the unstable break in the pitching moment curve at a moderate value of over-all lift coefficient to the initiation of stalling at the tip region. Another interesting feature was the formation of a "bubble" vortex lying parallel to the leading edge of the wing at low incidences, under the separated laminar layer. At higher incidences, complex vortex patterns were discovered, and the initial stalling at the wing tip was found to be associated in some way with the growth and inward movement of a standing vortex, with axis normal to the surface, which forms on the leading edge.

From author's summary

3667. **Acum, W. E. A., Corrections for symmetrical swept and tapered wings in rectangular wind tunnels,** *Aero. Res. Counc. Lond. Rep. Mem.* 2777, 33 pp., Apr. 1950, published 1953.

In this report it is shown that, in the case of wings with straight leading and trailing edges, the interference upwash due to the images of the wing in the wind-tunnel walls may be determined in terms of three functions, I_1, I_2, and I_3, of the parameters defining the size of the wing and tunnel. These functions have been tabulated and used to estimate the effect on C_L and C_M for wings of a variety of sizes and shapes. The variation of mean induced incidence with sweep and taper was found to be small. A formula is given for computing the residual correction to C_M for each special case. In the cases computed, the corrections to aerodynamic center were found to be negligible for most purposes.

From author's summary

3668. **Bratt, J. B., and Wight, K. C., The effect of sweepback on the fundamental derivative coefficient for flexural motion,** *Aero. Res. Counc. Lond. Rep. Mem.* 2774, 22 pp., Oct. 1950, published 1953.

Measurements have been made with new equipment, designed for derivative tests in a 9 × 7-ft tunnel, to determine the effect of sweepback on the derivatives $\lambda_{\dot\phi}$ and λ_ϕ for a rectangular airfoil of aspect ratio 6. A numerical reduction was observed in each case, amounting to 15% for λ_θ and 20 to 30% for λ_ϕ over the range $\omega = 1.0$ to 1.5 with a sweepback angle of 41.3 deg.

Values of $\lambda_{\dot\theta}$ and λ_θ for the swept model were obtained from measurements relating to oscillation about an axis perpendicular to the leading edge.

A comparison of $\lambda_{\dot\phi}$ and λ_ϕ with available theoretical results for finite aspect ratio is made and good agreement observed in the case of the former. The less satisfactory agreement with λ_ϕ is thought to be due to the lower accuracy of the theoretical values. Some difficulty was experienced in the interpretation of the measurements on the swept airfoil due to distortion of the model during oscillation. The effect is examined in detail in an appendix and a method of correction devised.

A comparison between measurements of $\lambda_{\dot\phi}$ for the unswept airfoil and earlier measurements made with the same model by the method of decaying oscillations gives satisfactory agreement.

From authors' summary

3669. **Legendre, R., Flow around an oscillating delta wing at large angle of incidence** (in French), *Rech. aéro.* no. 35, 3–6, Sept.-Oct. 1953.

A large angle of incidence allows a simplification of the equa-

tions governing a flow and permits a quick determination of the flow around an oscillating wing. A discussion of the results shows that the approximation is valid only for a wing whose wave length in the longitudinal direction is sufficiently large in comparison with the wing span and for a sufficiently long period of oscillation. From author's summary by Y. C. Fung, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 3489)

3670. Broadbent, E. G., The elementary theory of aeroelasticity, Parts I, II, III, *Aircr. Engng.* **26,** 301, 302, 303; 70–78, 113–121, 145–153, Mar., Apr., May 1954.

As indicated in the subtitle, these are a series of articles written from the standpoint of a structural engineer for students and junior members of aircraft-design teams. As such, they might be considered as textbook material for a course on flutter and divergence. Part I deals with divergence and control reversal; part II with wing flutter; and part III with flutter of control surfaces and tabs. The concluding article of the series, part IV, will deal with various guiding principles for avoiding or eliminating flutter. A. A. Regier, USA

3671. Jones, W. P., Supersonic theory for oscillating wings of any plan form, *Aero. Res. Counc. Lond. Rep. Mem.* 2655, 11 pp., June 1948, published 1953.

A theory for thin wings of any planform describing simple harmonic oscillations of small amplitude in a supersonic air stream is developed. It is based on the use of the generalized Green's theorem in conjunction with particular solutions which vanish over the characteristic cone with vertex at any point in the field of flow.

The theory can be used to calculate the aerodynamic forces acting on fluttering wings when the modes of distortion are known.

From author's summary by H. N. Abramson, USA

3672. Hall, A. H., A simplified theory of swept wing deformation, *Nat. aero. Establ. Canad.* LR 19, 21 pp., 1953.

See AMR 6, Rev. 93.

3673. Diederich, F. W., and Foss, K. A., Charts and approximate formulas for the estimation of aeroelastic effects on the loading of swept and unswept wings, *NACA Rep.* 140, 48 pp., 1953.

Supersedes article reviewed in AMR 6, Rev. 1029.

3674. van Spiegel, E., and van de Vooren, A. I., On the theory of the oscillating wing in two-dimensional subsonic flow, *Nat. LuchtLab. Amsterdam Rap.* F.142, 21 pp., Nov. 1953.

In this report, a short survey of the theory of Timman and van de Vooren for the oscillating wing is given. The pressure distribution is also derived by using a method which is a generalization of Hofsommer's method for the incompressible case. It is proved that the solution of Timman satisfies the integral equation of Possio. In the appendix the kernel of Possio's equation has been reduced to a form given by Küssner. However, the expression found in this report deviates slightly from that of Küssner.

From authors' summary by H. P. Liepman, USA

3675. Halfman, R. L., and Ashley, H., Aeroelastic properties of slender wings, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 907–916, 1952.

Aerodynamic loads on slender pointed wings executing arbitrary small motions perpendicular to the main stream direction are calculated independently by aid of an extension to unsteady motion of R. T. Jones' momentum theory and by aid of lifting-surface theory in which the approximation of small aspect ratio is introduced. The two methods agree.

It follows from these results that a rigid, plane delta wing free to pitch about a spanwise axis will show divergence if the axis lies aft of the two-thirds chord point. For axis positions more than a small distance ahead of this point, damped oscillations occur. For two axis positions, frequency and damping have been determined experimentally, leading to good agreement for the frequency but to values of the damping which are lower than the theoretical values. Single-degree-of-freedom pitching flutter is impossible.

For a chordwise-flexible delta wing, flutter and divergence were shown to exist both theoretically and experimentally. The flutter analysis included four degrees of freedom, viz., vertical translation, pitch, and two chordwise bending modes. The second bending mode is poorly damped and leads to flutter.

A. I. van de Vooren, Holland

3676. Meller, A. G., Preliminary study of compressor blade flutter (in French), *ONERA NT* no. 18, 33 pp., 1953.

Searching for an expression of a vibrating blade cascade described by Bellenot and Lalive [*Brown Boveri Rev.* **37,** p. 368, Oct. 1950], author simplifies the problem of a cascade consisting of straight and thin blades with front perpendicular to the undisturbed flow. To find the forces on the blades, he uses Küssner's method originally established for a single wing.

He then decomposes the cascade into sections of three blades each, assuming that in the first approximation the displacement of a blade has no influence on other blades than the two neighboring ones which are supposed fixed.

Starting from the vortex distribution of Birnbaum, he determines the coefficients of series expansion by imposing at 5 points of the profiles the condition that the fluid follows the contour, thus obtaining a system of 10 equations for the 10 unknowns, which are determined by the method of Cramer.

Having found the aerodynamic forces acting on the "elementary group" due to the harmonic movement of a single blade between two fixed ones, the forces acting on the blades in the cascade assembly are obtained by superposition, the "method of section" being applied under the assumption of its validity in this particular case.

Using the equations of Lagrange, he then establishes the equations of motion, and from the eigenvalues of the corresponding matrix the critical flutter speeds are obtained.

The result seems to show that, under the assumed hypothesis, flutter of Birnbaum type could not exist. This appears to be in contradiction to reviewer's experience [op cit.]

C. Bellenot, Switzerland

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 3471, 3488, 3490, 3738)

3677. Acosta, A. J., Note on the effect of meridian curvature. Supplement to "Potential flow through radial flow turbomachine rotors," *Hydrodynamics Lab. Calif. Inst. Technol. Rep.* no. E-19.5, 17 pp., Apr. 1954.

The effect of meridian curvature in a centrifugal impeller is estimated by assuming that the meridian streamlines may be replaced by "two-dimensional" surface of revolution. For the analysis, a shape was chosen that made the potential flow on this surface easy to solve. It is found that the slope of the streamline at the blade inlet is quite important for the determination of the

flow rate for shockless entry. If the solidity is somewhat greater than unity, the shockless condition is relatively independent of the exit inclination. The head, however, shows little dependence on the inlet, but is a function of the exit slope.

R. C. Binder, USA

3678. **Hamrick, J. T., Mizisin, J., and Michel, D. J., Study of three-dimensional internal flow distribution based on measurements in a 48-inch radial-inlet centrifugal impeller,** *NACA TN* 3101, 64 pp., Feb. 1954.

The flow distribution throughout the passage of a rotating impeller has been studied in detail and the results are presented in the form of relative velocity and relative pressure-loss contours at six levels between the impeller hub and shroud. These were constructed from the total-pressure measurements taken at numerous positions from blade to blade and hub to shroud and from static pressure measured on the impeller hub.

It is found that, except for extreme off-design conditions, the pressure loss near the impeller driving races is small and, in at least one radial position for each weight flow, there is a high loss region near the shroud at approximately 80% of the passage width from the driving face. The authors suggest an explanation of these phenomena based on considerations of secondary flow and clearance effect.

Comparison of data from the internal measurements made for the impeller of this investigation with the hot-wire anemometer studies made at the outlet of a similar impeller indicates that much can be learned about the internal-flow picture with hot-wire survey alone.

B. T. Chu, USA

3679. **Brown, T. W. F., High temperature turbine machinery for marine propulsion, Part I—Steam turbines, Parts II & III—Gas turbines,** *Engineer, Lond.* **197**, 5113, 5114, 5115; 122–127, 158–161, 194–196, Jan., Feb. 1954; also *Chartered mech. Engr.* **1**, 4, 162–203, Apr. 1954.

Present practice in high-temperature land and marine steam-turbine design is examined. The possibilities of future development of reheating by steam, gas, and liquid metal, assessing maximum gains and giving special attention to future marine propulsion turbines, are discussed. The cooled gas turbine is particularly studied and shown to have greater potentialities for improvement than the steam turbine.

From author's summary

3680. **Eckert, B., with the cooperation of Schnell, E., Axial and radial compressors. Application, theory, calculation [Axialkompressoren und Radialkompressoren. Anwendung, Theorie, Berechnung],** Berlin, Springer-Verlag, 1953, x + 441 pp., 426 figs., 6 tables. DM 73.50.

Book may be used as text and for reference. It contains some recommendable representations for phenomenological understanding of radial and axial compressors, such as choice of type and representation of performance on the basis of nondimensional analysis. Numerous data are presented with respect to controllability; e.g., adjustable guide vanes, stators and rotors, also partial admission. Practical consideration is made of wall losses, effect of Reynolds number, and hub-to-tip radius ratio. Many different kinds of stages covering large ranges of mass flow are represented by performance graphs. Instructive examples for numerical layout, even of a nine-stage compressor, may prove very helpful to students and beginners.

More modern data—unclassified—could have been used to better advantage. Most of the methods and material presented date back to 1945 or earlier and have been used, e.g., in BuShips 338 of Navy Department. Missing completely are data on supersonic compressors and their theoretical principles; even references to A. Weise's earlier attempts toward them are omitted. Theory is based mostly on cascade performance; there are only rudimentary attempts toward axisymmetric-flow considerations, though equilibrium conditions are somewhat considered. Practically nothing is said about secondary-flow phenomena. Completely omitted is the theory of finite blade number in radial pumps, as started by Kucharski and continued by Spannhake and Busemann, which is important also for axial compressors, if radial components have to be considered in the rotors.

Alphabetic index should have been much more complete and included more cross references. Though there are numerous literature references, especially European ones, at the end of the book, they are difficult to use since they are not tied in directly to the text. The figures, though numerous and valuable, cannot be fully exploited since many of them do not contain complete information for their practical use and for mutual comparison.

One cannot suppress the feeling that progress in this field in the past ten years has been faster in the United States than in Europe. Someone, eliminating the mentioned shortcomings, should write a book of similar style on the basis of these advances rather than translate the reviewed book.

F. Weinig, USA

3681. **Schnittger, J. R., Vortex flow in axial turbo machines,** *Trans. roy. Inst. Technol. Stockholm* no. 74, 62 pp., 1954.

After a brief survey of Traupel's, Meyer's, and Marble's results, author proceeds to the integration of general equation of radial equilibrium. Simplifying assumptions are frictionless, incompressible flow with rotational symmetry and without external forces (flow within clearance between blade rows). Author introduces a further simplification by integrating the general equation between inner and outer walls, thus applying condition of radial equilibrium to the fluid considered as a whole between the walls, which are furthermore assumed to be cylindrical. For a first approximation, a linear variation of c_u^2/r is taken along the radius. In dealing with the term $c_a(\partial c_r/\partial_z)$, author introduces Stokes' stream function ψ and assumes a radial function $c_a = a + (b/r)$ in the clearance, which also makes the integration easier.

Application of the theory is made to a first inducing stage of a compressor with $\nu = 0.6$ hub-tip ratio and is extended to the four first stages of a periodic machine, thus showing stabilization process.

Author states that no quite exact agreement was obtained after three successive iterations. Reviewer believes that this is partly due to the more or less arbitrary radial functions chosen for the first integration. It seems therefore necessary to improve these first assumptions, but this will result, in turn, in more intricate integrations. At the present time it is a question whether author's calculation method will present some practical advantages over usual procedures, consisting in computing the asymptotic velocity triangles by means of simplified radial equilibrium condition and applying afterward adequate corrections (Ruden, Siestrunck) in order to obtain flow conditions immediately upstream and downstream of the blades. Anyhow, author's attempt will be fully appreciated and will stimulate further investigation along similar lines.

P. Schwaar, France

3682. **Reeman, J., and Buswell, R. W. A., An experimental single-stage air-cooled turbine, Part I. Design of the turbine and manufacture of some experimental internally cooled nozzles and blades,** *Instn. mech. Engrs. Proc. (A)* **167**, 4, 341–350, 1953.

Paper discusses the design and manufacture of an experimental single-stage air-cooled turbine. The data obtained from this turbine could be used to design a turbine for a gas-turbine power plant. The primary objective of the project was to provide a

turbine on which rotational tests could be conducted at gas-inlet temperatures up to 1200 C (2192 F). The turbine was designed to permit tests on internally cooled blades with holes running the whole length of the blade to carry the cooling air and with root-cooled blades where the heat is removed by the cooling air from the root of the blade. The turbine was designed for a pressure ratio of 1.38 and weight flow of $22^1/_2$ lb/sec at a speed of 9000 rpm. In cooling the turbine, the design objective was to keep all metal temperatures of lightly stressed parts under 1600 F and heavily stressed parts under 1100 F. The cooled nozzles and blades which contain cooling holes of 0.030 and 0.040 inches in diameter were manufactured, using powder metallurgy and sintering with cadmium core material. Details on the manufacturing process are clearly described. In addition, a description of the method of rotor instrumentation is included.

G. R. Fusner, USA

3683. Ainley, D. G., Part II. Research on the performance of a type of internally air-cooled turbine blade, *Instn. mech. Engrs. Proc.* (*A*) **167,** 4, 351–370, 1953.

Paper discusses the results of the test on a turbine, described in part I of the paper (preceding review). Analysis of the test data indicates that, when a quantity of cooling air amounting to 2% by weight of the total gas flow through the turbine is fed to the row of rotor blades, an increase in gas temperatures of approximately 520 F should be permissible above the maximum value for a row of uncooled blades made from the same material. The tests indicated that the degree of cooling throughout each blade was not uniform and that large thermal stresses resulted. However, the author points out that the consequences of these stresses are not detrimental. The paper gives very complete test data and photographs of the turbine and components. Equations which can be used to determine the effect of cooling on the stage aerodynamic efficiency are also included. The author concludes that the results of the test relating to both the cooling characteristics of the blade and the aerodynamic losses created by the cooling system clearly demonstrate the practical feasibility of air-cooling gas turbines.

G. R. Fusner, USA

3684. Maynard, J. D., and Steinberg, S., The effect of blade-section thickness ratios on the aerodynamic characteristics of related full-scale propellers at Mach numbers up to 0.65, *NACA Rep.* 1126, 55 pp., 1953.

The results of an investigation of two 10-foot-diam, two-blade NACA propellers are presented for a range of blade angles from 20° to 55° at air speeds up to 500 mph. These results are compared with those from previous investigations of five related NACA propellers in order to evaluate the effects of blade-section thickness ratios on propeller aerodynamic characteristics.

The envelope efficiencies of all the NACA propellers are high at the lower rotational speeds at which the adverse effects of compressibility are small. The highest efficiencies, about 93% at a helical tip Mach number of 1.1, reflect the importance of using thin efficient airfoil sections throughout the blade. For propeller operation at constant rotational speed and power at helical tip Mach numbers below 0.8, a reduction in blade-section thickness from 12 to 8% at the 0.7-radius station, or approximately one third all along the radius, results in gains in propeller efficiency up to 10%.

The maximum efficiency of a propeller operating at a helical tip Mach number of 1.1 and Mach number of advance of 0.625 may be increased approximately 20% by reducing the blade-section thickness from 12 to 5% at the 0.7-radius station. At this same condition of operation for propellers having blade-section thicknesses between 12 and 8% at the 0.7-radius station, the maximum efficiency increases approximately 3% for each decrease in thickness of 1% at this station. For blade-section thicknesses between 8 and 5% at the 0.7-radius station, the rate of increase in propeller efficiency with reductions in thickness may still improve the maximum efficiency of propellers operating at high forward speeds with helical tip Mach numbers as high as 1.1.

From authors' summary by R. M. Crane, USA

3685. Gruber, J., On the problem of judging blade sections of axial hydraulic machines, *Acta Techn. Hung. Budapest* **7,** 1–2, 19–28, 1953.

3686. Stephenson, J. M., Measurement of the profile drag of compressor and turbine cascades and the effect of wakes in exciting vibration, *J. roy. aero. Soc.* **57,** 515, 722–725, Nov. 1953.

Author proposes an equation for use in calculating cascade profile drag from wake surveys, including the effect of the velocity head defect as well as the total pressure defect in the traverse plane. An approximate equation is derived, accounting for the effect of compressibility, by assuming the curve of total pressure defect to be an error curve. Rapid drag estimation is thereby provided, since relatively few total pressure measurements need be made in the wake. Application of Fourier series to a row of error curves representing wakes yields the amplitudes of the various frequency components for use in estimation of vibration stimuli on downstream blade rows in multistage axial turbomachines.

W. G. Cornell, USA

3687. Carlson, R. M., and Jacoby, D. R., A note on the contribution of higher mode resonance to bending in the teetering rotor blade, *J. aero. Sci.* **20,** 11, 791–792, Nov. 1953.

3688. Sabersky, R. H., Effect of wave propagation in feed lines on low-frequency rocket instability, *Jet Propulsion* **24,** 3, 172–174, May-June 1954.

A monopropellant rocket system is analyzed, consisting of a gas-pressurized propellant tank, a feed pipe, and a rocket motor. Compressibility of the liquid propellant is taken into account. The combustion delay (time lag) is taken as constant. One-dimensional frictionless flow is assumed and the method of small perturbations is used in the analysis. The frequency equation of the system is derived and the stability investigated by determination of the critical frequencies and the corresponding critical time lags. Besides the critical points which determine the neutral conditions of the system, additional points and slopes of the real part of the frequency are calculated. This real part of the frequency is plotted against circular frequency and time lag. An illustrative example is presented in which the influence of feed-pipe length is investigated. It is shown that stability of the whole system is not always achieved by lengthening of the feed pipe and that, for a given time lag, the frequency of operation may not change greatly with pipeline length.

T. P. Torda, USA

3689. Geckler, R. D., and Sprenger, D. F., The correlation of interior ballistic data for solid propellants, *Jet Propulsion* **24,** 1, 22–26, Jan.-Feb. 1954.

A self-consistent set of empirical equations is presented for describing concisely the most important performance parameters of a solid-propellant rocket motor. These equations relate the propellant burning rate, propellant temperature, chamber pressure, and area ratio so that the designer can construct a coherent set of correlations from only fragmentary data. The problem of propellant variability also is examined and a number of relations among the variances of the various parameters are obtained.

From authors' summary by S. S. Penner, USA

3690. **Price, E. W., Charge geometry and ballistic parameters for solid propellant rocket motors,** *Jet Propulsion* **24**, 1, 16–21, Jan.-Feb. 1954.

Solid-propellant rocket interior ballistics is formulated in terms of dimensionless variables and in a manner intended to exhibit the influence of certain performance parameters. Analysis applies only to internal-burning cylindrical charges, no end burning, in which the burning surface area varies linearly with the thickness burned. The performance parameters considered are the charge mass and the three ratios: burning surface area to nozzle throat area, burning surface area to internal channel cross-section area, and nozzle throat area to internal channel cross-section area.

J. Lorell, USA

Flow and Flight Test Techniques

(See also Revs. 3622, 3650, 3756)

3691. **Spink, L. K., and Howe, W. H., Flowmeter engineering,** *Instrum. and Automat.* **27**, 5, 783–787, May 1954.

Head-type flow-rate meters will continue to lead the field. Important factors in use of such meters include (1) choice of primary element—orifice, venturi tube, flow nozzle, flow tube, pitot tube, centrifugal element, or special element; (2) choice of orifice taps—corner, flange, vena-contracta, or pipe taps; (3) Reynolds-number correction; and (4) choice of differential-pressure instrument—wet or dry. Also discussed are the new electromagnetic, sonic, and mass flowmeters.

From authors' summary

3692. **Kunkel, W. B., and Talbot, L., Ion tracer technique for airspeed measurement at low densities,** *NACA TN* 3177, 31 pp., Mar. 1954.

Paper qualitatively surveys aerodynamic problems and techniques of ion-tracer velocity measurement, with particular emphasis on applicability to low-density flow. From aerodynamic standpoint, authors discuss relation of velocity and Mach number precision, relation between velocity accuracy and localization, flow disturbance due to ion production, and ion-detection devices. From technique standpoint, they discuss ion production by electron impacts, positive ion collision and photo-electric effect, ion detection by induction, and ion collection. They conclude that technique is applicable to low-density flow work.

Appendix describes NACA Ames Laboratory ion-pulse true-airspeed indicator of pulsed discharge, unshielded electrode detector type, for low-density supersonic wind tunnels. Low-density velocity measurement failed until detector was changed to shielded probe. Velocity measurements are given. Clear indication is given of superiority of shielded detector probes in low-density measurement. Authors also conclude that for 0.1-mm Hg region, pulsed electric discharge does not give sufficiently concentrated ion cloud. They recommend electron beam ion source in spite of complexity. Reviewer believes results in Appendix are interesting, significant, and merit development beyond sketchy beginnings.

H. G. Stever, USA

3693. **Sommer, F. L., Special-purpose Venturi tubes,** *Instruments* **27**, 1, 126–127, Jan. 1954.

3694. **Hall, J. G., The design and performance of a 9-inch plate Mach-Zehnder interferometer,** *Univ. Toronto Inst. Aerophys. Rep.* no. 27, 26 pp., Mar. 1954.

A Mach-Zehnder interferometer with 9-in.-diam plates has been constructed for use with the Institute of Aerophysics 2-in. × 7-in. shock tube and 5-in. × 7-in. supersonic wind tunnel. Design features of the instrument, procedure for adjustment, operation for flow studies, and performance are discussed. Some typical interferograms and schlieren and shadow photographs obtained with the instrument are included.

From author's summary

3695. **Waddell, J. H., High-speed photography,** *Mech. Engng., N. Y.* **76**, 5, 411–413, May 1954.

3696. **Heijne, L., Schagen, P., and Bruining, H., Television pick-up tube for both light and x-ray pictures,** *Nature* **173**, 4396, p. 220, Jan. 1954.

3697. **Girerd, H., Some experimental results on transonic flow** (in French), *Rech. aéro.* no. 35, 13–24, Sept.-Oct. 1953.

This is a review of recent experimental work in France, summarized from references cited. Pressure distributions are shown for transonic bump, circular-arc airfoils, diamond profiles, and profiles with varying position of maximum thickness. Agreement with transonic similarity theory is illustrated. Drag coefficients are given for profiles with varying position of maximum thickness. There is also a transonic drag curve for delta planform and for rectangular planform of aspect ratio 2. A lift-drag Mach-number palar is shown for the latter case.

A. Roshko, USA

3698. **Wemelsfelder, P. J., A new method of measuring waves by means of a simple set of counters named Integration-method** (in Dutch), *Ingenieur* **66**, 19, B.53–B.60, May 1954.

3699. **Swindells, J. F., Hardy, R. C., and Cottington, R. L., Precise measurements with Bingham viscometers and Cannon master viscometers,** *J. Res. nat. Bur. Stands.* **52**, 3, 105–120, Mar. 1954.

In agreement with other standards laboratories, the National Bureau of Standards (USA) has adopted the value of 1.002 centipoises for absolute viscosity of water at 20 C as primary standard for viscosity determinations. For secondary standards the Bureau made a critical study of Bingham viscometers and Cannon kinematic viscometers. Authors' summary states: "All corrections applicable to measurements with these instruments were critically examined. Instruments of each type were calibrated using the viscosity of water at 20 C as the primary viscosity standard. The viscometers were used to determine the viscosities of four hydrocarbon liquids in range 0.4 to 40 centipoises. With each liquid, the values obtained in the two types of viscometers were in agreement by 0.05% or better, indicating that no gross error was involved in the use of either instrument. It is considered, however, that the inherent relative simplicity of operation of the kinematic viscometer makes it a preferable instrument for this type of measurement."

A possible redesign of the bulbs of the kinematic viscometer is suggested by the authors. Experimental values and correction factors are presented for each type.

D. Aronson, USA

3700. **Woods, L. C., The second-order terms in two-dimensional tunnel blockage,** *Aero. Quart.* **4**, part 4, 361–372, Feb. 1954.

Paper deals with a computation of the solid and wake blockage for compressible subsonic flow about symmetrical two-dimensional bodies placed midway between tunnel walls. Author replaces the previous linear perturbation theory of compressible flow about a line-source distribution by a method based on an

integral equation. This equation yields more accurate results, particularly at high Mach numbers, and is exact for incompressible flow. It is not valid, however, in the transonic range. Essentially new is the computation of second-order terms which are given in the paper.

The effect on blockage of a possible increase in the boundary-layer displacement thickness on the tunnel wall, due to the body, is investigated and a method of computing the total blockage from wall pressure measurements is given.

B. G. van der Hegge Zijnen, Netherlands

3701. Daily, J. W., and Deemer, K. C., The unsteady-flow water tunnel at the Massachusetts Institute of Technology, *Trans. ASME* **76**, 1, 87–94, Jan. 1954.

The hydraulic, control, and measuring apparatus for a unique water tunnel are completely described, and some typical results are presented in this logically presented paper. Although the working model described is a small-scale model of a proposed larger apparatus, the major problems of control and instrumentation have been completely solved. Water is forced by compressed air from a large tank through 99 inches of 1-in. ID vertical pipe into a second tank. Range of variables includes velocities to 100 fps, accelerations to 5 fps² for 20 sec or higher (35 fps² run described) for shorter periods, and local pressures from 4 psia upward. Forcing air is controlled by a critical-flow control valve in response to commands from a cam-driven programming device. Servo-type control using special pressure transducers assures faithful response.

Instrumentation is based on diaphragm differential transformer-type pressure cells of special design to assure fast response, and all operating data are recorded on a 24-channel oscillograph. Natural frequencies of all cells exceed 165 cps in actual operating position, and satisfactory operation for several months without servicing is reported.

Initial tests check steady-flow pipe-friction coefficients and show that the friction factor for unsteady flow based on the average instantaneous velocity is essentially equal to that for steady flow based on the same velocity.

P. G. Hubbard, USA

Thermodynamics

(See also Revs. 3603, 3715, 3717, 3721, 3728, 3730, 3735, 3748, 3749, 3772)

3702. Smith, J. M., Thermodynamics, *Indust. Engng. Chem.* **46**, 5, 947–952, May 1954.

A survey of developments during 1953. Ed.

3703. Morrey, C. B., Jr., On the derivation of the equations of hydrodynamics from statistical mechanics, *Proc. nat. Acad. Sci. Wash.* **40**, 5, 317–322, May 1954.

Highly mathematical. Paper gives only main results, a long paper containing proofs and discussion having been submitted to another journal. The derivation mentioned in the title is made using the so-called Gibbs approach without recourse to the usual superposition assumption. D. ter Haar, Scotland

3704. Godridge, A. M., Some properties of gas mixtures, *Brit. Coal Utilisat. Res. Assn. Bull.* **38**, 1, 1–21, Jan. 1954.

Author reviews the theory, experimental methods, and published literature on the specific heats, viscosities, and thermal conductivities of nitrogen, oxygen, hydrogen, water vapor (steam), air, carbon monoxide, carbon dioxide, and methane. Reliable specific heat data over a large temperature range for these gases and gas mixtures are tabulated. Maximum temperatures at which reliable data on viscosity and thermal conductivity for these gases and gas mixtures appear to be available are in many cases very low. Author emphasizes need for additional experimental work, especially at high temperatures. An excellent bibliography is included.

A. Ramachandran, India

3705. Rowlinson, J. S., Sumner, F. H., and Sutton, J. R., The virial coefficients of a gas mixture, *Trans. Faraday Soc.* **50**, part 1, 1–8, Jan. 1954.

A simple expression is proposed for calculating the virial coefficients of a gas mixture from those of the pure components. A third virial coefficient is computed numerically and compared with two other approximations which, on the whole, are not as satisfactory. From authors' summary by R. A. Gross, USA

3706. Basset, James, and Basset, Jacques, Equation of state of gases. Measurement method of volume variation of fluids up to 10,000 kg/cm² pressure and 200° C temperature, and method of temperature measurement up to 1200° C (in French), *J. Phys. Radium* **15**, 1, Suppl., 47A–56A, Jan. 1954.

3707. Faxen, O. H., Ångtabeller. Thermodynamic tables in the metric system for water and steam, Stockholm, Nordisk Rotogravyrs monografiserie/Hafte 2, 1953 (International ed. Forskning och Technik 2), 147 pp. 19 Sw. Cr.

The tables of water and steam properties are based on a consideration of the available published data to 1953. The units employed are the meter, kilogram, second, with the absolute joule [IXth (1948) International Paris Conference of Weights and Measures] as unit of energy. The pressure unit employed is the bar equivalent to $^1/_{1.01325}$th of a standard atmosphere (a 76.0-cm column of mercury at 0° C in a field of 980.665 dynes). The absolute watt is taken equal to 0.99981 times the mean international watt. The steam or IT calorie then becomes equal to 4.18684 absolute joules.

The temperature scale of the tables is degrees centrigrade with the thermodynamic Kelvin temperature of the normal ice point taken as 273.16. The well-corroborated critical pressure and temperature values of water, 221.29 bars and 374.15 C, are chosen. The equation for $C_p°$ (specific heat of steam for zero pressure) employed is as follows:

$$C_p° = 1.8430 + 3.978 \times 10^{-4}t + 3.10^{-7}t^2 \qquad [A]$$

The computation of the zero-pressure specific heat of steam from spectroscopic data has now attained a point worthy of much confidence. Comparison of the values from equation [A] and the tabulation published by the National Bureau of Standards [*Nat. Bur. Stands. Rep.* no. 2535, June 1953] appear in Table 1 below.

TABLE 1 $C_p°$ IN ABSOLUTE JOULES

° K	Eq. A	NBS Pub.
300	1.8539	1.8639
400	1.8983	1.9005
500	1.9487	1.9544
600	2.0051	2.0162
700	2.0675	2.0818
850	2.1723	2.1847

The equation of state for steam is taken from the work of Jan Jůza, who made a careful study of the voluminous and accurate enthalpy measurements of J. Havliček and L. Miskovsky, collaborators in the international steam-properties investigations of about 20 years ago. The smoothed enthalpy (i) measurements provide the data for computing $(\partial v\tau/\partial\tau)$ $(\tau \equiv T^{-1}\ °K)$ from

which, with established reference values of $(v\tau)$, unknown volumes can be computed. Júza showed that the volumes derived from the enthalpy data were in good accord with directly measured values.

Table 1 A for constant pressure includes values for the volume of the liquid state as a function of temperature which are based on Professor Keenan's formulation [see sect. 4, page 20, "Thermodynamic properties of steam," Keenan and Keyes, John Wiley and Sons, Inc., N. Y., 1936]. The liquid values along with the superheated steam entries form a very convenient table. The temperature intervals for volume, enthalpy, and entropy are ten centigrade degrees starting with 0 and extending to 650 C (1202 F).

Table 1 A is followed by 1 B for superheated steam at constant volume tabulated from 0.004 to 100 cubic meters per kilogram.

Table 2 A contains saturation properties, pressure, volume, enthalpy, and entropy for each degree centigrade for the liquid and the vapor phase. Table 2 B lists values for dp/dT along the saturation line as well as $T\ dp/dT$ to the critical temperature.

Table 3 A tabulates values of pv/T from 1 to 300 bars from 110 to 650 C in 10° intervals and is accompanied by a diagram of the values. Table 3 B gives the pv/T values along the saturation line.

Table 4 A gives values of temperature, enthalpy, entropy, and moisture (x) for constant volumes, while 4 B lists values for constant x. Table 4 C gives values of the moisture, x, enthalpy, and entropy for wet steam at constant pressure.

Tables 4 and 5 are for heat conductivity of steam and the dynamic viscosity. A diagram of each property is also given.

The tables are completed by a clear and easily read 17.5 by 19.5-in. Mollier chart.

These new tables are arranged in convenient form. The choice of type and quality of printing are excellent. The most noteworthy omission is a saturation table with pressure as the argument. On the other hand, many tabulations are included which do not ordinarily appear in steam tables prepared for engineering use.

F. K. Keyes, USA

3708. Cobigo, M. H., Contribution to the study of low pressure injectors. Application to blue-flame gas burners (in French), *Mém. Soc. Ing. civ. Fr.* **106**, 5, 206–248, 1953.

The mechanical efficiency of an injector is defined as the ratio of the product of the fluid volume entrained and the pressure difference from the inlet to the outlet to the product of the volume of entraining fluid and the pressure excess of the supply of this fluid. This efficiency is measured for the simple cylindrical injector and for the injector with a divergent exit, and it is shown that the optimum distance of the nozzle from the entrance to the injector throat is 1 to 5 times the diameter of the latter. The efficiency increases steadily with the diameter of the injector throat so that a free jet gives the largest efficiency. With the divergent exit the efficiency increases steadily as the length of the divergent portion is increased. By applying these results it is possible to design gas burners injecting up to the whole of the combustion air having stability with gases ranging from 220 to 3300 Btu/ft^3.

Author states that there is no literature on this subject; but he has not seen Report no. 39 (1948) of the Gas Research Board of Britain, "The calculation of air entrainment in gas burners," by R. S. Silver.

M. W. Thring, England

3709. Keesom, W. H., Bijl, A., and Monté, L. A. J., The log T vs. S diagram of helium (in French), *Appl. sci. Res.* (*A*) **4**, 1, 25–32, 1953.

Using the available experimental data, the calculations required to plot the isochoric, isenthalpic, and isobaric curves for helium in the gaseous, vapor, and liquid phases are performed. The temperature range covered extends from 1 K to 500 K, and the pressure range from 0.001 atm to 300 atm. The results are shown graphically in a plot of log T vs. S, a logarithmic ordinate scale being used to enlarge the interesting heterogeneous region. The slope of the isobars yields $1/c_p$; of the isochores, $1/c_v$. The precision of the diagram is claimed to be better than 1% as far as the values of entropy, enthalpy, and pressure are concerned. The diagram, plotted at Leyden in 1941 and containing more than 100 curves, is, however, exceedingly difficult to read owing to its relatively small size (14 cm × 23 cm).

R. Heller, USA

3710. Nelson, L. C., Fellow, R. C., and Obert, E. F., Generalized pvT properties of gases, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-194, 32 pp.

Two sets of generalized compressibility charts are presented: One set is based upon critical temperatures and pressures, as in the past; the second set is based upon pseudo-reduced coordinates from the Lennard-Jones force potential. In both sets the underlying data are more extensive than those used in constructing older charts, since a complete survey of existing pvT data was made. The results of this survey for 30 gases are contained in a bibliography of 275 items which has been constructed to show the extent of the experimental data by including the ranges of pressure and temperature for each item. Although the charts are intended for engineering computations, the chart for the low-pressure region (p_r = 0 to 1), for example, has a deviation of 1% for 26 gases.

From authors' summary by J. A. Beattie, USA

3711. Skotnicky, J., The dependence of the melting point on the pressure, *Czech. J. Physics.* **3**, 3, 225–231, Sept. 1953.

This is a paper from the Czechoslovak *Journal of Physics* by a physicist from the Institute of Medical Physics at Kosice. It ostensibly is directed at further enlightenment on the dependence of the melting point of pure solids on the pressure when the solid is subjected to a different pressure than is the liquid. Experimental results are cited.

During the development of his subject, however, author points out, correctly, two errors in P. W. Bridgman's "A collection of thermodynamic formulas" [*Phys. Rev.* **3**, 1914], and laments the fact that these errors have been perpetuated since 1923 in each of the subsequent printings of "Thermodynamics and the free energy of chemical substances" by Lewis and Randall. This reviewer believes the author has overdrawn the importance of these errors, as on study of the original (1914) paper of Bridgman, they appear to be typographical in nature. While the author is correct that errors do exist in Bridgman's 1914 paper in *Physical Review*, he is incorrect when he states that "throughout thirty years no one doubted the correctness of the given equations." The fact of the matter is that Bridgman himself supplied the necessary corrections 11 years later in his fairly well-known book, "A condensed collection of thermodynamic formulas" [Harvard Univ. Press, Cambridge, Mass., 1925, pp. 13 and 14]. There is no reason to believe that this volume is not available to European scientists. As regards Lewis and Randall's book, author refers to the "23rd edition." What he probably means is 23rd printing, as this book has had only one edition, that being in 1923, two years before Bridgman published corrections to his 1914 paper. Although this review is not intended as a justification of any sort for the existing discrepancy on this point in Lewis and Randall, it will refocus the problem in the light of what appears to be more complete information.

The errors under discussion involve the two functions $(\partial A)_U$ and $(\partial A)_H$, where $A = U - TS$. The first function is written $(\partial A)_U$

$= -T(\partial S)_U - S(\partial T)_U$. In the 1914 article in *Physical Review*, this function is printed omitting the second term $-S(\partial T)_U$, as is evident after brief inspection. The second function $(\partial A)_H$ is printed correctly except for the second term which is given as $P(\partial V/\partial P)_T$ and should be $C_p P(\partial V/\partial P)_T$.

J. A. Clark, USA

3712. Liang, S. C., On the calculation of thermal transpiration, *J. phys. Chem.* **57,** 9, 192–201, Dec. 1953.

In low-temperature, low-pressure experimental investigations, the device measuring the pressure in the low-temperature system is frequently at atmospheric temperature. Author points out that thermal transpiration of the gas may significantly influence the accuracy of the pressure measured in this manner. Effect is particularly important if the diameter of the tube connecting the pressure-measuring device to the system is of the same order of magnitude or less than the mean free path of the gas molecules.

Author presents an equation for calculating the effect of thermal transpiration on pressure measurements. Rather than continuing to use nitrogen as the standard for the calculation, author proposes using as a standard, helium, which has the smallest collisional diameter and the largest thermal transpiration effect. In relating thermal transpiration effect to molecular diameters, author points out some disagreement with published diameter values.

Reviewer believes paper to be of particular interest to those working in vapor pressure measurements and low-temperature adsorption studies.

R. L. Young, USA

3713. Dolecek, R. L., and Madden, J. J., A mechanical heat switch, *Rev. sci. Instrum.* **24,** 11, 1063–1064, Nov. 1953.

3714. Jordan, R. J., and Threlkeld, J. L., Solar heat collectors used with heat pumps, *Heating and Ventilating* **51,** 4, 96–98, Apr. 1954.

Heat and Mass Transfer

(See also Revs. 3494, 3602, 3652, 3682, 3683, 3702, 3704, 3712, 3713, 3714, 3767, 3769, 3773)

3715. Eckert, E. R. G., Heat transfer, *Indust. Engng. Chem.* **46,** 5, 932–936, May 1954.

A survey of developments during 1953.

Ed.

3716. Ingersoll, L. R., Zobel, O. J., and Ingersoll, A. G., Heat conduction with engineering, geological and other applications, rev. ed., Madison, The University of Wisconsin Press, 1954, xiii + 325 pp. $5.

The original text, entitled "Mathematical theory of heat conduction," was published over 40 years ago. In 1948 the work was expanded to nearly double the original in volume, with the consequence that the title was changed to "Heat conduction—with engineering and geological applications." In the present volume, two new chapters on the theory of heat earth exchangers (chap. 13) and on the drying of porous solids (chap. 14) have been added. The former discusses the use of the ground as a source of heat and the latter introduces the theory of soil consolidation—a topic of growing interest in the field of soil mechanics. No change has been made in the first 12 chapters when compared with the 1948 revised edition.

The book should be appropriate as a classroom text at the advanced undergraduate level. The subject matter discussed is of diversive interest. Applications include such varied topics as diurnal and annual temperature fluctuations, periodic heat flow in engine cylinders, shrink fittings, quenching of steel ingots, annealing of optical mirrors, post-glacial calculations, design of fireproof walls, formation of geysers, cooking and canning operations, ice formation, etc. Much of the material is presented from the engineer's viewpoint in that liberal assumptions are introduced to make possible the simple lucid analysis. The mathematical prerequisite necessary for understanding the text material is only a knowledge of college calculus. It is in this latter respect that the book may also serve as a reference to geologists and engineers who have not the background of higher mathematics.

A short discussion of graphical and numerical methods commonly used in solving heat-conduction problems is also included.

For those who are expected to handle more difficult problems as they arise or those who are interested in applied mathematics, reviewer believes that Carslaw and Jaeger's excellent treatise on "Conduction of heat in solids" is, perhaps, more useful. More powerful mathematical methods are presented in the latter text.

B. T. Chao, USA

3717. Weeks, J. L., and Seifert, R. L., Apparatus for the measurement of the thermal conductivity of solids, *Rev. sci. Instrum.* **24,** 11, 1054–1057, Nov. 1953.

Apparatus developed within restrictions that a small sample (0.1875 × 0.1875 × 1.75 in.) must be mounted in or removed from apparatus by remote control and that thermocouples must not be joined to specimen. Method is similar to that of Van Dusen and Shelton [*J. Res. nat. Bur. stands.* **12,** 429–440, 1934]. Thermal conductivities of several anisotropic materials are reported. In range from 40 C to 100 C, authors report probable error in measurement is 20% for solids of low thermal conductivity (quartz) to 3% for solids of high thermal conductivity (Armco iron).

R. J. Grosh, USA

3718. Giulianini, A., On the distribution of temperature in the internal walls of unsteady-state thermal equipment (in Italian), *Termotecnica* **7,** 6, 227–230, June 1953.

Author's problem is known [Carslaw-Jaeger, "Conduction of heat in solids," Oxford, 1948: chap. III, Linear flow of heat in the solid bounded by two parallel planes] and is of technical interest for heating apparatus. Reviewer considers author's mathematical process questionable.

G. Sestini, Italy

3719. Datzeff, A., Heat conduction in a nonhomogeneous rod (in French), *Godishnik, Univ. Sofia* **47,** sec. 1, part 2, 1–32, 1950/1951–1951/1952.

Paper is an important mathematically rigorous contribution to the analytical theory of linear heat conduction. It contains several problems.

The fundamental question concerns temperature distribution in a thin rod of finite length and with the surface impervious to heat. General initial and boundary conditions are considered. New is the assumption of variable thermal parameters—conductivity, specific heat, and mass of the material.

Author subdivides the body in question into n parts and approximates his problem by referring to a rod of many homogeneous parts (the well-known multilayer problems). Its mathematical expression is given by n simultaneous partial equations and n Volterra integral equations. Solution of the original problem is then obtained for $n \to \infty$.

Resulting general formulas serve as the starting point for the study of some important special cases. First comes the steady temperature field in a nonhomogeneous rod. Then follows a question about heat conduction in a semi-infinite rod under general initial and boundary conditions. Article ends with the case of a finite rod under the most general linear conditions at the boundaries.

Author's conception is, no doubt, a very original one. His paper shows new possibilities of applying abstract theory successfully to advanced questions of theoretical physics and engineering. V. Vodička, Cezchoslovakia

3720. Pochapsky, T. E., Determination of heat capacity by pulse heating, *Rev. sci. Instrum.* **25,** 3, 238–242, Mar. 1954.

A description is given of apparatus used to measure the heat capacity of metal wires by pulsed heating. The electrical energy supplied to the wire is determined with respect to a platinum standard while the temperature rise is determined from the change in resistance and the measured temperature coefficient of resistance. A maximum error of 5% in the specific heat might be expected with the apparatus as built, but the results agree with most published data to within a few per cent in the range 0 C to 650 C. From author's summary

3721. Deissler, R. G., Analysis of turbulent heat transfer, mass transfer, and friction in smooth tubes at high Prandtl and Schmidt numbers, *NACA TN* 3145, 53 pp., May 1954.

Present paper is a continuation of the subject matter treated in *NACA TN* 2629 [AMR **5**, Rev. 2122]. The analysis expounded there is modified for the case of high Prandtl and Schmidt numbers in that in the region close to the wall an expression is assumed for the eddy diffusivity which accounts for the effect of viscosity in reducing turbulence near the wall. For the rest, essentially the same simplifying assumptions are made. Velocity, temperature, concentration distributions, and heat and mass transfer are calculated at Prandtl and Schmidt numbers between 0.5 and 3000.

The objection raised in the above-mentioned review, to the assumption of equal diffusivities for momentum and heat or mass, still applies. Particularly in the case of high Prandtl numbers it would lead to discrepancies between predicted and actual temperature distributions. No measurements of temperature distributions are given, however. But since there is good agreement between predicted and experimentally found heat and mass transfers, apparently for this case, at least, the assumption discussed seems allowable.

Further calculations are given for (a) the entrance effect for heat or mass transfer, which at high Reynolds numbers decreases with increasing Prandtl or Schmidt number, and (b) the effects of variable viscosity across the tube on heat transfer and friction. J. O. Hinze, Holland

3722. Kays, W. M., London, A. L., and Lo, R. K., Heat-transfer and friction characteristics for gas flow normal to tube banks—use of a transient-test technique, *Trans. ASME* **76,** 3, 387–396, Apr. 1954.

This experimental analysis was purposely designed to emphasize a method based on transient response for calculating the heat-transfer and friction characteristics of gas flow normal to tube banks in a heat exchanger. The analysis is based on a one-dimensional heat transfer by forced convection where radiation, free convection, and conduction are negligible. The method proves to be very satisfactory if carried out in accordance with the limitations imposed by the simplified heat equation. Authors show remarkable correlation between the heat-transfer characteristics obtained by the transient method and those obtained employing steady-state techniques.

Heat-transfer and friction characteristics were measured for flow normal to circular tube bundles for a range of Reynolds numbers (tube diameter) between 500 and 20,000 and for transverse pitch ratios ranging from 1.25 to 2.50 and longitudinal pitch ratios between 0.75 to 1.50. S. Eskinazi, USA

3723. Ostrach, S., Note on the aerodynamic heating of an oscillating surface, *NACA TN* 3146, 12 pp., Apr. 1954.

Theoretical study of heat transfer from infinite plane surface to an infinite extent of incompressible fluid when surface oscillates parallel to itself, generating heat in the fluid through viscous dissipation. Constant fluid properties and no body forces are assumed. Solution is given for step function change of surface temperature from equilibrium temperature (equilibrium being where temperature variation at any point in fluid is purely oscillatory). No application of solution is suggested. A. E. Bryson, Jr., USA

3724. Bugaenko, G. A., Free thermal convection in vertical cylinders of arbitrary cross sections (in Russian), *Prikl. Mat. Mekh.* **17,** 4, 496–500, July–Aug. 1953.

General analytical solution of free thermal convection equations is derived to determine velocity and temperature distributions inside vertical cylinders for laminar fluid-flow case. Author starts with Navier-Stokes, continuity, and Fourier equations and uses methods similar to Pohlhausen's for vertical plates to reduce the problem to that of solution of Laplace equation for temperature—and Poisson equation for velocity distribution; he concludes that temperature distribution resembles that of stationary medium because of orthogonality of velocity to temperature gradient. Above differential equations are integrated and boundary conditions discussed for two specific cases. Thus distributions are obtained for cross sections of rectangular cylinder and of circular cylinder bounded by a solid. H. Hurwicz, USA

3725. Petuchov, B. S., and Krasnoshchekov, E. A., Examining heat transmission during the viscous flow process of a liquid in rectangular canals and in round pipes (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 865–881, June 1953.

Description of testing apparatus and of experiments on forced heat convection in two mineral oils of very widely different viscosity when moving through a rectangular canal (3.3 × 17 mm wide) with small Reynolds numbers (< 2300). The results of these experiments, as well as those of Böhm [*Die Wärme*, no. 15, 1943], of Sherwood, Kiley, and Mangsen [*Indust. Engng. Chem.* no. 3, 1932], and of Sieder and Tate [ibid., no. 12, 1936] in round pipes, can be summarized in two formulas for the relative temperature difference of the liquid $\Theta = (t_1 - t_2)/(t_1 - t_s)$ (t_1 temperature of the entering fluid, t_2 mean temperature of the outflowing fluid, t_s temperature of the inner wall of the pipe). The difference is a function of the geometrical form of the pipe section, of Péclet's number, of the ratio d/l (d equivalent diameter, l length of the tube), of Prandtl number, and of the ratio μ_s/μ_1 (μ_1 viscosity of the entering fluid, μ_s mean viscosity of the fluid in the tube). The dependence upon these last two numbers is different when the direction of heat transfer is changed. A. Kuhelj, Yugoslavia

3726. Yih, C.-S., Free convection due to a point source of heat, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 941–947, 1952.

A point source of heat is considered to be situated in an infinite plane above which the atmosphere was originally isothermal and at rest, and the resulting steady temperature and velocity distribution are sought. As can be observed from the behavior of smoke from a burning cigarette, the flow caused by the heat source is laminar at first, then at some height above it becomes unstable, and the subsequent flow is turbulent. The interdependent distributions of temperature and velocity are obtained in the laminar zone by solving a pair of simultaneous differential equations, and in the turbulent zone by systematic experimentation guided by a dimensional analysis. The transition from

laminar to turbulent flow is also investigated. The results are applicable to similar problems of diffusion.

From author's summary by R. M. Drake, Jr., USA

3727. Surinov, Yu. A., Zonal method of calculating radiative heat transfer in combustion chambers (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 992–1021, July 1953.

3728. Gardon, R., A segmented-mirror solar furnace for high-intensity thermal radiation studies, *Rev. sci. Instrum.* **25,** 5, 459–463, May 1954.

This solar furnace consists of a battery of 400 flat mirrors 3 in. × 3 in., back silvered, held in light copper frames and mounted on a rigid steel plate. A secondary mirror reflects the collected radiation to the sample. The arrangement of the mirrors is such that radiation of practically uniform intensity is produced, up to about 5.5 cal/cm²/sec over an area of about 5 cm². Edge effects are kept to a minimum; for example, in tests of samples of pinewood. Guiding is not required for most tests, which last only a few seconds. The furnace is of simple design, forming a box of $5^1/_2$ ft × $5^1/_2$ ft × 7 ft long and equipped with alt-azimuth mounting.

W. M. Conn, USA

3729. Wright, G. M., A direct reading thermistor thermometer for aircraft use, *Nat. aero. Establ. Canad.* LR-65, 6 pp., June 1953.

3730. Rocard, Y., Theory of condensation, equilibrium of vapor in the presence of droplets (in French), *C. R. Acad. Sci. Paris* **238,** 11, 1198–1200, Mar. 1954.

Brief statement of results of a statistical mechanical treatment of the pressure difference existing between center of liquid drops and vapor at the surface, up to the region of the critical temperature. Author states that thermodynamics gives only some of these results, in the first approximation, of the effects of surface tension. Earlier statistical mechanical theories do not predict the calculated behavior of the pressure difference nor predict supersaturation, it is stated. A result unobtainable from thermodynamics is that near the critical temperature the excess of the actual vapor pressure over the saturated vapor pressure is much greater than the pressure difference between center of the liquid drop and vapor pressure at the surface.

M. Gilbert, USA

3731. Goufman, I. N., Amelin, A. G., and Levi, S. M., Theory of thermogradient drying of films, *Nat. Sci. Found.* tr-213, Feb. 1954; *Doklady Akad Nauk SSSR (N.S.)* **92,** 4, 759–762, Oct. 1953.

Analysis of a method of rapidly drying photographic film, plates, etc., which tends to prevent formation of hard surface layers and eliminates dust deposition on the film. Experimental drying rates were twice as large as computed rates, which was ascribed to fog formation. The formation of fog was treated in a qualitative manner.

W. L. Sibbitt, USA

3732. Kirschbaum, E., Mathematical and graphical treatment of evaporation (in German), *ZVDI* **95,** 27, 927–932, Sept. 1953.

Using continuity and energy equations, a modified Mollier diagram is proposed to represent evaporation of a liquid into a gas. Lines of constant relative humidity, constant wet-bulb temperature, and constant adiabatic saturation temperature may be shown in such a diagram.

Paper contains also some experimental results for evaporation of water into air.

T. Y. Toong, USA

3733. Smith, E. L., and Ballard, O. R., A method for calculating the evaporation from water sprays in an icing tunnel, *Nat. aero. Establ. Canad.* LR-60, 21 pp., May 1953.

3734. Hsu, N. T., Sato, K., and Sage, B. H., Material transfer in turbulent gas streams, *Indust. Engng. Chem.* **46,** 5, 870–875, May 1954.

Rates of evaporation of liquid drops of *n*-heptane were measured by a photographic technique while the drops hung from fine capillary tubes in a jet of air. The results were correlated by an equation similar to one proposed several years ago by Frossling [*Gerlands Beitrage Geophys.* **51,** 167, 1937] and modified more recently by Ranz and Marshall [*Chem. Engng. Progr.* **48,** nos. 3, 4, 1952]. The new study presents new information on the influence of the shape of the drop on the total evaporation rate, showing that the rate for an ellipsoidal surface is slightly greater than that for a sphere having the same ratio of surface to volume. The new study also differs from the earlier ones because the fugacity of the diffusing component is used instead of the partial pressure. The observed rates agreed closely with those expected from Frossling's work.

R. L. Pigford, USA

3735. Pigford, R. L., Mass transfer, *Indust. Engng. Chem.* **46,** 5, 937–946, May 1954.

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3736. Dorsch, R. G., Brun, R. J., and Gregg, J. L., Impingement of water droplets on an ellipsoid with fineness ratio 5 in axisymmetric flow, *NACA TN* 3099, 50 pp., Mar. 1954.

Authors have computed water-droplet trajectories about an ellipsoid of revolution for the condition of incompressible air flow. Results are presented in terms of four dimensionless parameters: (1) Total rate of water impingement; (2) extent of droplet impingement zone; (3) distribution of impingement; and (4) local rate of impingement. The reported data should prove useful in anti-icing studies involving body shapes similar to the one investigated. The report represents an extension of prior NACA water-droplet trajectory studies pertaining only to airfoil shapes.

N. R. Bergrun, USA

3737. Brun, R. J., and Dorsch, R. G., Impingement of water droplets on an ellipsoid with fineness ratio 10 in axisymmetric flow, *NACA TN* 3147, 37 pp., May 1954.

Authors compute water-drop trajectories for an ellipsoid having fineness ratio 10 and present the results of their work in terms of certain dimensionless parameters. These parameters are: (1) total rate of water impingement, (2) extent of droplet impingment, and (3) local rate of water impingement. Calculations represent a continuation of a study reported previously for a similar body of fineness ratio 5 (see preceding review). Results for both fineness bodies are compared, and the authors conclude that while efficiency of impingement is almost the same in both cases, it is possible for sizably greater amounts of water to impinge upon the thicker ellipsoid because of its larger projected frontal area.

N. R. Bergrun, USA

3738. Wright, G. M., An aircraft icing-rate meter, *Nat. aero. Establ. Canad.* LR—66, 5 pp., June 1953.

3739. Larsen, B. M., Regenerator efficiency and air preheat in the open hearth, *J. Metals* **6,** 2, 129–144, Feb. 1954.

Paper covers a rather detailed study of the main aspects of regenerative air preheating of the refractory checkerwork type as applied to open-hearth furnaces. Author introduces subject with

very clear and concise story of the growth of the open-hearth process and problems created by this growth. Following the introduction is an interesting study of efficiencies in commercial furnaces with natural and forced air conditions. Account is detailed, leaving little for the reader to develop mentally as he proceeds through the equational and mathematical aspects of the subject. Important to all reports of this nature, the author establishes limitations within which the discussion is held so that the reader understands from the start the scope of the investigation. Automatic control of reversals in the furnace is discussed briefly to emphasize the problems involved. It would have been interesting to include at this point some reference to the continuous regenerative cycle of the so-called Ljungstrom principle which may offer possibilities for achieving the ultimate in efficiency and control.

Particular interest should be found in the summary and conclusions combining in very easy-to-follow form numerous details and aspects preceding.

Description of an aspirating-type high-velocity thermocouple is an added feature supporting the accuracy with which the investigation was made and emphasizing extent to which the researchers went in their efforts to produce useful and reliable data. The measurement of elevated temperatures under stratified conditions is a problem of enormous magnitude and importance. While the particular thermocouple used offers little in the way of new ideas, its presentation offers a means for creating added improvements in the design. J. Waitkus, USA

Combustion

(See also Revs. 3688, 3689, 3690)

3740. Wohlenberg, W. J., Interface-extension versus upper limiting time-mean energy-release rates of the constant-pressure steady-state combustion process, *Trans. ASME* **76**, 4, 679–687, May 1954.

Author considers diffusive burning of "elements" of fuel and air in a heterogeneous mixture produced by turbulent mixing. Combustion occurring at the interface of fuel and air elements is affected by the rate of diffusion of reactants (called tail-end diffusion) to the combustion zone. Under these conditions, author determines maximum element surface to volume ratio (called interface extension) required to produce a rate-of-energy release per unit volume equal to that for a homogeneous mixture. For the particular case of dodecane, the required element size is approximately equal to the thickness of the combustion zone.

J. A. Fay, USA

3741. Belles, F. E., and Simon, Dorothy M., Pressure limits of flame propagation of propane-air mixtures, *Indust. Engng. Chem.* **46**, 5, 1010–1013, May 1954.

A careful study of the relation of quenching effects—i.e., critical diameters for flame propagation—to pressure limits of flame propagation. It is limited to propane-air systems. Results show dp^{-n}, where d is minimum diameter for flame propagation through a circular opening. For propane, n varied from 0.97 for 4.03% mixtures to 0.76 for 2.5%. (Above 5%, phenomena such as oscillatory flames showed up, so data were not reported for richer mixtures.) These results are in good agreement with data of other investigators on minimum slit width for flash back and minimum electrode separations in spark ignition.

With large enough tubes (somewhat over 2 cm for propane air), a concentration "limit of flammability" can be determined which is characteristic of the fuel-oxidant system. For smaller tubes, a "pressure limit of flame propagation" is observed which is partially determined by quenching at the walls. There is no indication in these experiments of an absolute minimum of pressure at which flame propagation becomes impossible.

Results are also of interest for comparison with studies of burning velocities, tube diameters, and pressure [see, e.g., Culshaw and Garside, p. 204, in "Third symposium on combustion," Williams and Wilkins Co., Baltimore, 1949; and Gaydon and Wolfhard, *Fuel* **29**, 15, 1950].

R. C. Anderson, USA

THE FOLLOWING PAPERS (REVS. 3742–3749) WERE PUBLISHED IN Fourth Symposium (International) on Combustion, 1953; Baltimore, Md., Williams and Wilkins. $7.

3742. Russi, M. J., Cornet, I., and Cornog, R., The influence of flame holder temperature on flame stabilization, 743–748.

Paper describes the results of an experimental investigation made on the influence of flame holder temperature on the lean stability limit in homogeneous air-fuel streams of moderate velocity. An electrically heated cylindrical flame holder was used in a 3-in. diam nozzle. Heating the flame holder increased the lean stability limit, the limit varying linearly with temperature in the blowout velocity range of 20 to 45 fps, the maximum velocity investigated. Below a velocity of about 20 fps, varying the flame-holder temperature from 500 to 2000 F has essentially no effect on flame stability. A region of instability was observed, however, at stream velocities from 20 to 30 fps. Authors speculate that in this region two mechanisms of combustion are competing, and that instability may be caused by a transition from a small fixed eddy to a large oscillating type of eddy flow. A. C. Scurlock, USA

3743. Wilkerson, E. C., and Fenn, J. B., The effect of flame-holder geometry on combustion efficiency in ducted burners, 749–756.

An attempt is made to provide a quantitative mechanism for combustion in high-velocity burners. Authors contend that the combustion process consists of raising the temperature of the incoming air-fuel mixture by means of pilot heat to levels high enough to bring about rapid burning. They explain the problem of high combustion efficiencies as one of rapid mixing of sufficient pilot heat with the stream. The ability of various flame-holder configurations to mix pilot heat with the stream was determined, and an effective diffusivity of the stream K was associated with each configuration. With values of K to indicate the mixing ability of the pilot configurations, a correlation of combustion efficiency with K, which is formally consistent with the classical Arrhenius reaction rate equation and which describes experimental results within 5%, was developed. Although the validity of the relations arrived at is dubious, the existence of a definite relationship between combustion efficiency and the K factor associated with the igniter structure is demonstrated.

A. C. Scurlock, USA

3744. Singer, J. M., Burning-velocity measurements on slot burners; comparison with cylindrical burner determinations, 352–358.

True values of burning velocity are necessary for the rational analysis of flame problems and for testing theory of propagation. Measurements are made on rectangular burners (minimum 3:1 side ratio). The schlieren image of the straight-sided conical flame was treated by the Dery truncated-cone method. Constant values of burning velocity were found over 50% of the slot width. Errors due to curvature in circular burners are eliminated, giving values by the slot burner some 10% lower for methane, propane, and ethylene. Values of burning velocity are believed to be accurate to 2–3% by the slot-burner method;

satisfactory agreement is obtained with the latest spherical bomb data.

Reviewer believes that the author's confidence in the accuracy of the method is justified and welcomes the stated intention to extend measurements to effect of temperature and pressure. Further data on the pressure effect are vital to the checking of theories of flame propagation. N. P. W. Moore, England

3745. Dugger, G. L., and Simon, Dorothy M., Prediction of flame velocities of hydrocarbon flames, 336–345.

Knowledge of flame velocities of fuels is important for assessing the combustion efficiencies of ramjet burners. Authors have compared measured flame velocities for various hydrocarbons, initial temperatures, and mixture compositions with those predicted by three semitheoretical methods. These equations were derived using different models of the flame propagation process. A series of purely empirical correlations between flame speeds and various parameters are also presented. For engineering applications, it appears that satisfactory estimates may be made more easily by the empirical equations than by the semitheoretical ones. J. K. Kilham, England

3746. Byrne, J. F., The influence of atmospheric oxygen on Bunsen flames, 345–348.

In measuring flame speeds of gas-rich mixtures by cone dimension methods, it is well known that presence of secondary air leads to erroneous results. Using oxygen as an atmosphere around the flame and sampling the interconal gases, author concludes that ambient oxygen does not penetrate the flame cone of rich primary mixtures. Increasing oxygen concentration around rich hydrocarbon air flames does, however, increase the flame speed, and this is attributed to an increase in heat transfer from the outer flame to the primary reaction zone. Reviewer considers that more experimental results, e.g., temperature measurements in the preheat zone, are necessary before this theory can be accepted. J. K. Kilham, England

3747. Wohl, K., Shore, L., von Rosenberg, H., and Weil, C. W., The burning velocity of turbulent flames, 620–635.

Authors review the various theories of the effect of turbulence on flame speeds and compare the predictions with previous experimental data and new results obtained for butane-air flames issuing from a tube. They conclude that in the case of high-speed flames and rich flames there are mechanisms by which flame-generated turbulence increases the turbulent flame speed.

Some experimental results on enclosed turbulent flames are reported which indicate approach stream turbulence has a marked effect. W. Squire, USA

3748. Hirschfelder, J. O., Curtiss, C. F., and Campbell, Dorothy E., The theory of flames and detonations, 190–211.

Paper summarizes results in the theory of flame propagation developed in the authors' earlier papers [AMR **4**, Rev. 414; **5**, Revs. 2160, 2939; **6**, Rev. 2030, and *Univ. Wisc. Nav. Res. Lab. Rep.* CM690]. The conservation equations are generalized to include kinetic energy and viscosity terms. The nature of the solutions for first-order chemical reactions is discussed and illustrated by numerical examples for certain special cases: (1) Kinetic energy, viscosity, and diffusion neglected, the dependence of flame velocity on the strength of the heat sink at the cold boundary is examined; (2) kinetic energy and viscosity neglected and the effect of diffusion considered; (3) diffusion and viscosity neglected and variation of mass flow with the Mach number of the products calculated.

In the example given, the dimensionless mass flow parameter μ (the text reads, p. 206, item (4), "the mass rate—M", but this is clearly an error, as is item (2), which should read: M varies as the square root of pressure and the flame velocity as the inverse square root) remains surprisingly constant over the range of Mach numbers from 0 to 1. The authors point out that the latter value is the upper limit of flame speed and that, for a first-order reaction, this results in a lower pressure limit for stable flames. It should be observed that this limit is unlikely to be met experimentally, since the reaction process would cease to be first order at much higher pressures.

The final case discussed is that of gaseous detonation, where kinetic energy and viscosity are considered but diffusion is neglected. The qualitative behavior of solutions is presented. The paper is a useful contribution to the literature on the theory of combustion and detonation. G. K. Adams, England

3749. Friedman, J., Bennet, W. J., and Zwick, E. B., The engineering application of combustion research to ramjet engines, 756–764.

Authors of this paper attempt to show how the manufacturers of ramjet engines may make direct use of combustion research data in establishing design criteria for ramjet combustion systems. The four analytical tools used to correlate research and design data are: (1) Combustion stability, which is concerned with the requirement of flame holding; (2) fuel distribution in the engine; (3) combustion efficiencies, which are concerned with mechanism of heat release; and (4) the pressure loss associated with the flame-holding devices. These factors are discussed in detail and their use in the design of a typical combustion system is considered. On the basis of combustion research conducted in the past few years, the authors conclude that (1) the fuel-air ratio limits for stable burning of hydrocarbon fuels in ramjet engines may be correlated as a function of a characteristic dimension of the stabilizer and pressure, velocity, and temperature of the combustion mixture at the stabilizer; (2) control of the fuel distribution may be effected by proper design of the fuel injector; (3) the efficiencies of the combustion for a particular burner may be correlated as a function of fuel-air ratio, tail-pipe length, combustion-chamber inlet velocity, temperature, and pressure; and (4) a compromise must be effected in flame-holder design to obtain adequate stability limits and acceptable tail-pipe length without excessive pressure loss. A. C. Scurlock, USA

3750. Rekers, R. G., and Villars, D. S., Flame zone spectroscopy of solid propellants, *Rev. sci. Instrum.* **25**, 5, 424–429, May 1954.

The spectroscopy of burning solid propellants has been generally limited to a photographic integration of the various flame zones as a burning strand is consumed and the flame passes a spectrographic slit. A few instances have been reported in which separation of the spectral emission from the different zones of the flame has been attempted, but the results are deficient either through loss of resolution of the spectrograph system or shortness of exposure time. An automatic constant-level device is reported which permits the isolation and detailed exposure of a definite flame zone throughout the complete time of burning of a 72-in. length of strand. The strand is burned inside a bomb provided with four windows. Two diametrically opposite windows are circular and are used for the spectroscopic observations. At right angles to those two are two slotlike vertical windows used to admit and pass a control beam of light. This beam is focused upon the strand and passed on outside the bomb through a condensing lens onto a pair of photoelectric cells. By proper adjustment it is possible to make the motor feed the strand at almost exactly the same rate as the burning rate. A discussion of the technique, illustrated with typical data on the degree of control, is presented. Typical absorption and emission spectrograms are given.

From authors' summary by R. Delbourgo, France

3751. Downs, D., and Wheeler, R. W., Recent developments in "knock" research, *Instn. mech. Engrs., Auto. Div.*, part III, 80–99, 1951–1952.

Using an electromagnetic sampling value, authors found organic peroxides to be some of the most important intermediate products of combustion. Interesting cool-flame diagrams as well as hot- and cool-flame limit curves for various hydrocarbons are shown. Fuels are divided into two major classes: Those which knock by a high- and those which knock by a low-temperature mechanism. Most higher paraffinic and naphthenic fuels are of the latter type.

An extensive discussion of the NACA photos (by Millir, et al.) concludes that the high-speed flame photos show two stages of two-stage autoignition rather than autoignition followed by detonation.

This work supplements the authors' publication in the *Phil. Trans. roy. Soc.* (*A*) **243**, 1951. M. Rand, Canada

3752. Thurlow, G. G., Corrosion studies on a model rotary air-preheater, Instn. mech. Engrs., 6 pp., 1954.

Tests have been carried out on a 0.5-ft diam rotary (regenerative) air preheater with 0.167-ft depth of the rotor (and of the heating elements), using combustion gases with controlled addition of sulfuric acid and a (measured) dew point of 240 to 320 F. With matrix surface temperatures, measured by thermocouple, of 200–300 F, the rate of acid deposit and of corrosion (formation of ferrous sulphate) increases with temperature decreasing below the acid dew point and reaches a maximum between 67 to 25° below the dew-point temperature, at temperatures ranging from 215 F (at 0.002) to 245 F (at 0.006 vol. % acid conc.). At a given surface temperature the rate of corrosion increased rapidly with the concentration of acid. W. Gumz, Germany

3753. Barkley, J. F., Karlsson, H., Berk, A. A., Stark, C. F., and Burdick, L. R., Corrosion and deposits in regenerative air preheaters, U. S. Dept. Interior, Bur. Mines, Rep. of Investigations 4996, 23 pp., 59 figs., 9 tables, Aug. 1953.

Corrosion of and deposits on the heating surfaces of air preheaters for boilers limit the capacity and efficiency at which the equipment can be used. The elimination of corrosion and deposits could lead to a substantial reduction in the gas exit temperature of the boiler, while the latent heat of the moisture in the gases offers a valuable source of, at present wasted, energy. The possible gain in over-all fuel efficiency is such as to encourage various research programs with a lowering of gas exit temperature as their ultimate aim. At the same time, these researches are justifying themselves in the immediate help they are giving toward alleviating trouble occurring at the exit temperatures now being employed.

One excellent example of these research programs is described in the book under review, a program of full-scale and laboratory work carried out by the Air Preheater Corporation of America and the U. S. Federal Bureau of Mines over a $5^1/_2$-year period.

The major part of the investigation consisted of a study of the use of 66 different materials installed in a Ljungstrom rotary air preheater to an underfeed stoker-fired water-tube boiler under regular operation. The materials used included various steels and steel alloys, aluminum, copper, various coated and plated materials (i.e., lead, zinc oxides, etc.), and some ceramic tubes. The attack on these different materials obviously varied greatly, though there were three predominant characteristics to all deposits: partial solubility in water, the presence of sulphates, and acidity. The solubilities ranged from 13–98%, the soluble part being mostly sulphates. Over 30 trace elements were found, such elements as boron, gallium, etc., which occur in minute traces in the coal, accumulating in the deposits.

The solubility of the deposit and the corrosion of the plate were mostly related to the susceptibility of the material to sulphuric-acid attack. In general, it was found that all metals that form sulphates cannot be used for air-preheater plates without some corrosion and eventual plate failure.

Attempts were made to devise various simple laboratory corrosion tests to simulate, in a short time, the full-scale results. In these, test specimens were suspended in an acid fog and various sulphate and sulphuric acid solutions. The results were not entirely satisfactory (emphasizing the need to simulate also the mode of acid condensation before comparable conditions are obtained), but it was confirmed that, in addition to the plate material, factors such as temperature, gas composition, and the presence of deposits influence the corrosion. The importance of the initial "corrosion film" is emphasized; the early corrosion products can either inhibit or accelerate the subsequent attack.

The experimental results reveal a whole string of unsolved problems and possibilities, and various suggestions are proposed from this and other work of approaches toward eliminating or reducing fouling by preventing the acid forming, preventing it reaching the surface, or by preventing it attacking the plate. Methods of removing the deposits and corrosion products are also discussed.

Brief references are made to other complementary investigations, though the book does not contain an over-all survey of the work being carried out by the Boiler Availability Committee in Great Britain, the Swedish State Power Board, etc., on this subject.

The investigations are described clearly and fully, the report being amply illustrated with photographs and figures, and they make a valuable contribution to the data available. The report, however, is something more than an account of experiments and must serve to encourage and stimulate all people interested in what the authors term as "one remaining avenue to improved fuel efficiency." G. G. Thurlow, England

Acoustics

(See also Revs. 3536, 3613, 3645)

3754. Yarwood, T. M., Acoustics, London, Macmillan & Co., Ltd.; New York, St. Martin's Press, 1954, x + 346 pp. **$3.50.**

The special purpose of this book is to prepare the candidate for examination from the ordinary to the scholarship levels. Also, enough practical aspects are considered to appeal to first-year engineering students and others. Emphasis has been placed on the classical experiments in physics which nicely illustrate the subject matter. The mathematics is sufficient to provide insight into more advanced treatments of vibration theory. Even the accomplished technical worker in this field will enjoy such a thoughtful discussion of the fundamentals and thorough review of the applications.

Almost 200 questions and answers are given on the first ten chapters covering the theory. The remaining four chapters on practical aspects cover such subjects as musical scales, sound signaling, acoustics of buildings, and noise insulation.

E. G. Fischer, USA

3755. Kosten, C. W., and Kasteleyn, M. L., edited by, Proceedings of the First ICA-Congress Electro-Acoustics (in German), *Acustica* **4**, 1, 306 pp., 1954.

This issue contains the Proceedings of the First ICA-Congress Electro-Acoustics, held in the Netherlands from June 16 to 24, 1953. These proceedings are composed of 92 papers, grouped in seven sections under the following headings: Sound recording,

Public address systems, Acoustic measurements, Hearing aids and audiometers, Ultrasonic electro-acoustics, Electro-acoustics applied to musical instruments, Symposium on the sound insulation of lightweight structures. Ed.

3756. **Nomoto, O., Theory of the visualization of ultrasonic waves. Part I, Theory of the schlieren method for visualizing ultrasonic waves. Part II, Theory of the phase-shift method for visualizing ultrasonic waves,** *J. Phys. Soc. Japan* **9,** 2, 267–286, Mar.-Apr. 1954.

3757. **Ramachandra Rao, B., and Subba Rao, K., Investigation of ultrasonic velocities in liquids by a new method,** *Proc. Indian Acad. Sci.* (A) **39,** 3, 132–136, Mar. 1954.

Sound velocities in transparent liquids are measured by setting up standing waves between a quartz crystal and a brass reflector and measuring the frequencies of integral half-wave lengths by a Debye-Sears optical refraction method. These frequencies can be accurately located by this means, and measurements of a number of standard liquids give results in agreement with other methods.
W. P. Mason, USA

3758. **Parthasarathy, S., Chari, S. S., and Srinivasan, D., Variation of ultrasonic absorption with frequency in organic liquids,** *Acustica* **3,** 5, 363–364, 1953.

The absorption α of ultrasonic waves has been measured by a radiation pressure method at 5, 10, and 15 mc/s. The variation of α/f^2 with frequency f is discussed in relation to relaxation theory. In esters, generally, a pronounced decrease of α/f^2 with frequency occurs, thus justifying to some extent the relaxation theory. From authors' summary

3759. **Pyett, J. S., The acoustic impedance of a porous layer at oblique incidence,** *Acustica* **3,** 6, 375–382, 1953.

The specific normal impedance of a layer of anisotropic material for a plane wave impinging at oblique incidence is expressed by the characteristic impedance and the propagation constant of the material, the principal axis of which is assumed to be normal to the surface. Using a transverse mode in a rectangular guide in the frequency range of 2.4 to 4.8 kc, impedance measurements at oblique incidence are performed on layers of rock wool cut from slabs 2.3 cm thick. The results are in good agreement with the theory. F. E. Borgnis, USA

3760. **Powell, A., The influence of the exit velocity profile on the noise of a jet,** *Aero. Quart.* **4,** part 4, 341–360, Feb. 1954.

The effect of velocity gradients on the noise of jets is of both theoretical and practical interest. On the basis of Lighthill's theory, noise intensities from certain regions of the jet are related to the mean flow gradients. From a practical standpoint, the bypass engine provides a means for changing the exit velocity gradients.

The author attempts to evaluate experimentally the effect of modifying the velocity profile of a 2-in. jet by comparing the noise from a nozzle with a square velocity profile with that of pipe having a nearly fully developed turbulent flow profile. It is found that, based on the same velocity at the center of the jet, the noise from the pipe having the modified profile is $2^1/_2$ to 5 decibels lower than from the nozzle with the square profile. The thrust, however, is 26% less for the pipe than for the nozzle. Making comparison on a constant thrust basis, changing diameters, and velocities, it is found that holding diameter constant, the square profile gives less noise. If the comparison is made keeping maximum velocity constant and permitting diameter to vary, the modified profile produces less noise. Unfortunately, the experiments were made with two setups having different initial turbulence levels, which raises some questions as to the validity of the comparisons. A. A. Regier, USA

Ballistics, Detonics (Explosions)

(See Rev. 3466)

Soil Mechanics, Seepage

(See also Revs. 3587, 3620)

3761. **Peattie, K. R., and Sparrow, R. W., The fundamental action of earth pressure cells,** *J. Mech. Phys. Solids* **2,** 3, 141–155, Apr. 1954.

Paper reviews theoretical concepts of behavior of pressure cell in an elastic, homogeneous, isotropic material. It is postulated that cell errors are a function of the dimensional characteristics of the cell and a cell action factor which, in turn, is dependent upon the stress-deformation characteristics of both the cell and the soil mass, Poisson's ratio for the soil mass, and on the ratio of the pressure-sensitive area of the cell face to the total area of the face. Experimental investigations are described which were conducted to evaluate the above-listed factors. It is concluded that cell errors can be reduced to small and predictable proportions (for the type of cell used in the study) by (1) keeping the thickness-diameter ratio as small as possible, (2) having ratios of sensitive area to total face area less than 0.25 or 0.40, depending on cell construction, and (3) having the cell as incompressible as possible.
W. G. Shockley, USA

3762. **Nixon, I. K., Some investigations on granular soils with particular reference to the compressed-air sand sampler,** *Géotechnique, Lond.* 4, 1, 16–31, Mar. 1954.

3763. **Carpenter, J. C., and Barber, E. S., Vertical sand drains for stabilization of muck-peat soils,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 351, 17 pp., Nov. 1953.

3764. **Vargas, M., Correlation between angle of internal friction and angle of shearing resistance in consolidated quick triaxial compression tests on residual clays,** *Proc. Third. Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. 1, 72–75.

Considering that residual clays are generally in the form of a skeleton of coarse grains, each in its clay envelope, which gives the soil a typical nondilatant clay behavior, author generalizes Skempton's conclusions, in his study of the immediate triaxial compression tests, to interpret results of slow and consolidated quick tests on residual clays. A formula was deduced which correlates the angle of internal friction with the angle of shearing resistance in consolidated quick tests on such clays. The results of the tests confirm the calculated values.
From author's summary by O. Hoffman, USA

3765. **Breth, H., and Kuckelmann, G., Pore water pressure in earth dams. A report on pore pressure measurements** (in German), *Bautechnik,* **31,** 1, 25–29, Jan. 1954.

Authors pay particular attention to cases of unsaturated soils in their laboratory consolidation and compression experiments. The rise of pore water pressure does not attain 100%, which is probably the case in actual earth-dam works. Authors are confident that control of earth-dam construction can be accomplished through piezometer measurements and suitable laboratory experiments. T. Mogami, Japan

3766. Shestakov, V. M., Calculating seepage in earth dams and barriers with fluctuating water levels (in Russian), *Gidrotekh. Stroit.* **22**, 7, 36–39, July 1953.

The downstream water level is suddenly altered from one steady value to a different steady value. The transient motion of the water table inside a dam is studied, using Boussinesq's partial differential equation $(h^2)_t = (k/\mu)h(h^2)_{xx}$. This is linearized by replacing the undifferentiated symbol h with a parabolic expression in x correct at each face of the dam. The analytical solution so obtained, illustrated by graphs, should be an improvement on that of N.N. Verigin [title source, no. 3, 1952] and agrees well with a "hydraulic integrator" solution for case of semi-infinite dam.

Transient flow development is expressed in terms of dimensionless time variable and is effectively complete for typical structures when $kt \sim 1m$. Author concludes that transient seepage effects are important for fine-grained but not medium-grained sands. Transient hydraulic gradient at downstream face, however, can always be important, and a method of calculation is given. (k is the transmission coefficient, μ the storage coefficient, the remaining notation being standard.)

A. H. Armstrong, England

Geophysics, Meteorology, Oceanography

(See also Revs. 3714, 3736, 3737, 3738)

3767. Brooks, F. A., and Rhoades, D. G., Daytime partition of irradiation and the evaporation chilling of the ground, *Trans. Amer. geophys. Un.* **35**, 1, 145–152, Feb. 1954.

Study concerns daytime conduction and convection of heat at the ground, how added soil moisture magnifies the heat-flow cycle, and how latent heat of vaporization affects the diurnal temperature cycles. Measured diurnal cycles in dry soil are used to show how the amplitude and phase lag of temperature and heat-conduction waves are affected by net (solar plus long-wave) radiation, conduction, and convection. Similar measured data on lightly irrigated soil show the striking effects of moisture. Further investigation is needed to establish empirical coefficients for use with simplified formulas.

A. Whillier, USA

3768. Houghton, H. G., On the annual heat balance of the northern hemisphere, *J. Meteor.* **11**, 1, 1–9, Feb. 1954.

Increased knowledge of atmospheric radiation has made it desirable to recompute the heat balance of the northern hemisphere. Computations are based on observational data; no assumption is made regarding planetary albedo, nor albedo of clouds. Solar radiation reaching the surface is derived largely from the North American pyrheliometric network. These data are extended to the hemisphere on the basis of relative cloud amounts. Absorption of solar radiation in the atmosphere is computed from the original Smithsonian data. Absorption by clouds is taken into account. Outgoing long-wave radiation is computed on the Elsasser radiation chart using monthly mean data from a large number of individual stations. The planetary albedo is found to be 0.34, with a minimum of 0.28 in the subtropics and a maximum of 0.67 at the pole. About 19% of incident solar radiation is absorbed in the atmosphere, and 47% is absorbed at the ground. The computed poleward flux of heat is found to reach a maximum of 11.12×10^{19} cal/day across the 40°N latitude circle. This is 20 to 25% larger than earlier estimates. The hemispheric energy balance between the surface of the earth and the atmosphere indicates that the eddy flux of sensible heat is directed upward and that its magnitude is of the order of 10% of the solar radiation incident on the outer atmosphere.

From author's summary by A. Whillier, USA

3769. Frost, R., A power law representation of the heat transfer in the lowest 100 metres of the atmosphere, *Tellus* **5**, 4, 513–528, Nov. 1953.

Status of present views about magnitude, vertical variation, and equality or nonequality of exchange coefficients for heat and momentum in the first 100 meters of the atmosphere is given with special attention to work in England. Studies outside England are largely ignored. Author argues for approximate equality of heat and momentum exchange coefficients and for a power law vertical variation. Discussion of diurnal and annual temperature wave together with heat budget calculations concludes the paper. Lack of simultaneous measurements of the heat budget components (now available in United States under Air Force Cambridge Geophysical Directorate and in other work by F. A. Brooks, University of California, Davis) curtails author's verification of equations. Author's assumption of constant soil thermal properties is of doubtful validity; reviewer believes soil heat flow is a very complicated process. Considered as a review of work in England up to 1953, Frost's paper is outstanding.

R. C. Staley, USA

3770. Endlich, R. M., A study of vertical velocities in the vicinity of jet streams, *J. Meteor.* **10**, 6, 407–415, Dec. 1953.

Three-hour average vertical-velocity values are computed at the 500- and 300-mb levels under the assumption of adiabatic motion by the "isobaric" technique. The patterns of the isolines of vertical velocity (isanabats) are shown for several upper flow patterns. Vertical velocity values of 10 cm sec^{-1} are found to be common at both levels, and a maximum value of 25 cm sec^{-1} is given. Computational errors are felt to be smaller by an order of magnitude. The strong isanabatic centers are shown to lie in or near the jet stream, indicating that the jet is an important vertical transport mechanism. Cloud observations show good qualitative agreement with the computations. Limited evidence, based on a study of the vertical velocity patterns over the Northern Hemisphere for a 10-day period, indicates that the mean circulation around the jet stream is thermally indirect.

From author's summary

3771. Nyberg, A., and Raab, L., A remark on the energy transport from a warm river surface into cold air, *Tellus* **5**, 4, 529–532, Nov. 1953.

Temperature measurements in very cold air above an open river surface indicate that, in spite of very high temperature lapse rate (temperature of river, in the 2-cm, 10-cm, and 12-m levels are +0.5, −14.0, −15.3, and −18.0 C, respectively), the eddy conductivity is of the same order of magnitude as in extremely stable conditions (e.g., above a snow surface during nocturnal cooling).

From authors' summary

3772. Syôno, S., Note on the polytropic Exner function and its application to the theory of adiabatic chart, *J. meteor. Soc. Japan* (2) **31**, 9, 313–317, Sept. 1953.

3773. Gifford, F., Jr., An alignment chart for atmospheric diffusion calculations, *Bull. Amer. meteor. Soc.* **34**, 3, 101–105, Mar. 1953.

An alignment chart is presented by means of which nine of the most common equations on atmospheric diffusion, formulas due to Sutton, or any formulas comparable with these, may be quickly evaluated.

From author's summary

3774. Ogura, Y., Note on the wind velocity profile in the non-adiabatic atmosphere, *J. meteor. Soc. Japan* (2) **30**, 10, 329–342, Oct. 1952.

A theoretical equation representing the variation of wind with

height is derived for a nonadiabatic atmosphere in terms of the heat flux, Reynolds stress, and roughness parameter, assuming (1) energy supplied from the mean to the turbulent flow due to wind shear is balanced both by the dissipated energy of molecular viscosity and by the work done against gravity; (2) the lifetime of the largest turbulent element in a nonadiabatic atmosphere is the same as in an adiabatic atmosphere; (3) the vertical eddy flux of a property (momentum, heat or water vapor) is independent of height.

The theoretical results are compared with Deacon's observations and are found to be in good agreement. In addition, the results are compared with the theoretical findings of other authors emphasizing the important role of the dissipation due to molecular motions.

From author's summary by L. Machta, USA

Lubrication; Bearings; Wear

3775. Forbes, W. G., revised by Pope, C. L., and Everitt, W. T., Lubrication of industrial and marine machinery, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, viii + 351 pp. $6.50.

Book is second edition of one first published by Forbes in 1943. The first part describes the chemistry, refining, compounding, and specifications for lubricants, with the remainder being devoted to recommendations of lubricants suitable for specific machines or applications.

The treatment is empirical throughout, with very inadequate discussion of the phenomena of film lubrication, either thick or thin. Physical tests described are the conventional ones which in most cases have little bearing on the actual behavior or efficiency of lubricants. A serious lack is the complete omission of description or discussion of the numerous film-strength testing machines developed in the past few years. W. O. Richmond, Canada

3776. Bowden, F. P., and Thomas, P. H., The surface temperature of sliding solids, *Proc. roy. Soc. Lond.* (*A*) **223**, 1152, 29–40, 1 plate, Apr. 1954.

Further corroboration was obtained of the surface temperatures reached in the contact area between sliding solids for the case where one of the surfaces is transparent. Method utilized a lead sulphide cell for detecting radiation beneath the contact area between a fixed slider and a rotating transparent plate. Measurement of the direct radiation and that passing a filter of known transmission characteristics permitted calculation of the actual temperatures independent of radiating area with an accuracy of ± 50 C.

Experiments with several metals sliding on a glass disk indicated small transient hot spots occurring throughout the apparent contact area with light load and low speed. Both the surface temperature and the size of the radiating area increased with speed and load. In general, maximum temperatures were limited by the melting point of the slider, confirming previous measurements by another method [title source, **154**, p. 640]. A new observation was made in the case of metals which oxidize readily. Temperatures in excess of the melting point as a result of heat released by oxidation were noted.

Reviewer believes this is another important contribution to an understanding of the mechanism of friction and damage between sliding solids. J. B. Bidwell, USA

Marine Engineering Problems

(See also Revs. 3484, 3679, 3775)

3777. Burrill, L. C., and Emerson, A., Propeller cavitation: some observations from 16 in. propeller tests in the new King's College cavitation tunnel, *N. E. Cst. Instn. Engrs. Ship. Trans.* **70**, part 2, 121–150, 1953–1954.

The new tunnel is described and test results given on propellers of moderately high blade-area ratios and a series of merchant-ship propellers. An unusual feature of this new propeller-cavitation tunnel is the ability to circulate water in either direction, thus permitting propeller testing in the usual "open water" condition as well as under conditions simulating wake operation. Modifications of the propeller-shaft support structure permit modeling characteristic ship-wake patterns with the reverse flow. The tunnel has long closed-jet test section 40 by 32 in. in section and was built using parts of a German acoustic flow tank. Over-all, it is 40 ft long by 35 ft high and is driven by a 300-hp motor, thus producing test speeds up to 24 fps (17 fps in the reverse direction). The 16-in. test propellers are driven by a 100-hp dynamometer. No indication is given of the range of test pressures obtainable.

Of the three, four, and five-bladed propellers of the merchant-ship type tested, the three-bladed propeller was slightly better in terms of efficiency and delay of thrust breakdown due to cavitation. A narrow three-bladed propeller had higher efficiency but more serious cavitation. The other propeller series showed no significant differences due to the different blade sections used. No test results are given for the reverse flow condition except for two photographs indicating the occurrence of root (or hub) vortex cavitation.

Observations of propeller singing indicate a frequency range of 1000 to 5000 cycles and a correlation with advance ratio and cavitation index. One form of singing was clearly associated with the tip vortex cavity. The singing was a combination of one, two, or three frequencies rather than a pure note. It is concluded that models can be used to examine this phenomenon.

J. M. Robertson, USA

3778. Buermann, T. M., Leehey, P., and Stilwell, J. J., An **appraisal of hydrofoil supported craft,** *Soc. nav. Arch. mar. Engrs. Prepr.*, Ann. Meeting, Nov. 1953. Pap. no. 1, 25 pp.

3779. Williams, M. L., and Ellinger, G. A., Investigation of structural failures of welded ships, *Welding J.* **32**, 10, Oct. 1953.

Critical study of brittle fractures which occurred in service. Samples of 100 ships were examined. Chevron study allowed finding the source of fracture, which was: structural or metallurgical notches, rough oxyacetylene cutting, faulty welds, arc strikes, and arc craters. Origin of fracture was attributed to notch-sensitive steel, low temperature, stress concentration, quenching, and heavy loading. Excellent analysis of service failures. W. Soete, Belgium

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